



2002 Environmental Surveillance Report

**A compilation and explanation of data collected by
the INEEL Oversight Program during 2002**

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Abstract

After completing an independent assessment of the environmental conditions in the vicinity of the Idaho National Engineering and Environmental Laboratory (INEEL) during 2002, the state of Idaho's INEEL Oversight Program (INEEL OP) concluded:

- No offsite environmental impacts from INEEL operations were evident as a result of particulate air sampling.
- Tritium was detected in atmospheric moisture samples from two onsite-monitoring locations. However, these concentrations are significantly below risk-based threshold levels.
- No offsite environmental impacts from INEEL operations were evident as a result of milk or soil sampling.
- At monitoring locations on and near the INEEL, gamma radiation measurements remained within background levels.
- Of the contaminants that the INEEL OP monitors in groundwater, only tritium and chromium were above background levels near the southern boundary of the INEEL. However, concentrations were less than the EPA drinking water standards.
- Gross beta and strontium-90 concentrations detected in groundwater on the INEEL did exceed EPA drinking water standards; however, these detections were not from wells used for drinking water.
- The wastewater and groundwater verification program for onsite locations shows that most of the INEEL OP data were comparable with data from the primary contractor and the Naval Reactors Facility.
- Analytical data reported by surveillance programs of the INEEL OP and the U.S. Department of Energy (DOE) generally agree.

The state of Idaho will continue monitoring conditions at and near the INEEL to assess potential impacts on public health and the environment.

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Executive Summary

INEEL OP Environmental Surveillance Program 2002 Results

Introduction

To determine the impacts that INEEL activities may have on public health and the environment, the state of Idaho maintains the INEEL Oversight Program (INEEL OP). The INEEL OP provides independent assessments of contaminants resulting from DOE activities at the site. It monitors the condition of air, water, external radiation, and soil within the boundaries of the INEEL and air, water, external radiation, soil, and milk at offsite locations. Water monitoring efforts include groundwater, surface water, and effluent sample collection. The INEEL OP reports data from these environmental surveillance efforts quarterly and annually, and reviews data collected from previous years to identify any discernible trends. The INEEL OP's independent findings are used to compare with and supplement data reported by DOE environmental surveillance programs (ESP).

The DOE, likewise, maintains a surveillance network to assess any impacts that the INEEL may have on public health and the environment. Several organizations were responsible for carrying out the DOE's environmental surveillance program at the INEEL during 2002. As the INEEL prime contractor with DOE, Bechtel BWXT Idaho, LLC (BBWI) measured external gamma radiation and analyzed environmental samples of air, drinking water, and soil; made *in-situ* soil measurements within the boundaries of the INEEL; and performed limited sampling offsite.

Also contracted by DOE, the S.M. Stoller Corporation's Environmental Surveillance Education and Research Program (ESER) provided environmental surveillance outside the boundaries of the INEEL, and to a limited extent, within the boundaries. Environmental measurements made by ESER included external radiation, analysis of airborne particulate matter, water (drinking and surface), animal tissue, foodstuffs (milk, potatoes, wheat, and lettuce), and soil. Argonne National Laboratory-West (ANL-W) performed the monitoring at that facility, and Bechtel Bettis conducted monitoring at the Naval Reactors Facility (NRF). Groundwater surveillance was

conducted primarily by the United States Geological Survey (USGS), which samples aquifer wells on the INEEL and throughout the Eastern Snake River Plain.

The INEEL OP does not attempt to duplicate the DOE's extensive surveillance network. Instead, select locations are sampled to provide a representative overview of the environment on and around the INEEL. Comparison with DOE's data is accomplished by analyzing samples of air, soil, milk, and water collected at the same place and approximate time. In those instances where the INEEL OP collects samples at different locations and/or with different instruments, or for different analyses, the subsequent results supplement data collected by the other organizations.

The following sections briefly describe the INEEL OP's environmental surveillance programs, summarize the 2002 surveillance results, discuss identified trends, and present comparisons of the data reported by the INEEL OP and various DOE monitoring programs.

Air Monitoring

Air Monitoring - Particulate Matter and Gaseous Radionuclides

Monitoring Network and Instrumentation

In 2002, the INEEL OP operated ten air-monitoring stations strategically located on and around the INEEL. Data for samples collected at an air monitoring station in Fort Hall operated by the Shoshone-Bannock Tribes are also included in this report. At the ten INEEL OP operated locations, high-volume total suspended particulate (TSP) samplers operate continuously collecting particulate matter. The INEEL OP began using high-volume TSP samplers in 2001 as the primary particulate air samplers after the completion of a two-year investigation comparing these samplers to the PM₁₀ samplers historically used by the INEEL OP.

To supplement the particulate air sampling, three intermediate-flow PM₁₀ samplers are operated continuously collecting particulate matter with an aerodynamic diameter less than 10 micrometers at three of the ten INEEL OP operated locations mentioned above. A charcoal cartridge designed to adsorb gaseous radioiodine is placed in series following the particulate filter within each PM₁₀ sampler.

Sample Collection Methods and Analysis

Sample collection and analysis followed regular schedules and written sampling and analysis plans as well as procedures. On a weekly basis, INEEL OP staff collected the filters and charcoal cartridges from the PM₁₀ and filters from the TSP samplers. Filters were analyzed with gas-flow proportional counting to measure gross alpha and gross beta radioactivity. Charcoal cartridges were analyzed with gamma spectroscopy to detect gamma-emitting radionuclides, with specific reporting of iodine-131. On a quarterly basis, the filters were composited by location and analyzed with gamma spectroscopy for man-made, gamma-emitting radionuclides, with specific reporting of ruthenium/rhodium-106, antimony-125, cesium-134, and cesium-137. TSP samples

from all four quarters of 2002 were then composited by location and analyzed radiochemically for strontium-90, plutonium-238, plutonium-239/240, and americium-241.

Results, Trends, and Interprogram Comparisons

Air monitoring results for 2002 are summarized below, as are any trends identified through the evaluation of air monitoring data collected by the INEEL OP since 1994. In addition, these results are compared to those reported by DOE's ESP at four air monitoring stations that are co-located with those operated by INEEL OP.

Gross Alpha and Gross Beta Radioactivity Results

Particulate air samples collected during 2002 showed concentrations of airborne radioactivity at typical historical background values. Elevated gross alpha and gross beta concentrations observed are likely due to elevated concentrations of longer-lived radon progeny trapped in the lower atmosphere during periods associated with temperature inversions. These conclusions are supported by gamma spectroscopy and radiochemical analyses results as discussed below.

Trend analysis of gross alpha and gross beta radioactivity data collected by the INEEL OP since 1994 shows that both measurements fluctuate following natural seasonal patterns at each of the sample sites.

Direct comparisons of gross alpha and beta screening measurements with other programs were difficult to quantify due to variations in air-sampling methodologies between these programs. However no significant disagreements were noted.

Iodine-131 Results

No iodine-131 was detected on charcoal cartridges collected in 2002, and none has been detected since the INEEL OP began air sampling in 1994. Similarly, the DOE monitoring programs did not report any iodine-131 detections during the 2002 sampling period.

Gamma Emitting Radionuclide Results

Gamma spectroscopy performed on the 2002 quarterly composited particulate filters did not detect the presence of man-made, gamma-emitting radionuclides.

Beryllium-7, a naturally occurring cosmogenic radionuclide, was reported above the minimum detectable concentration of the laboratory. The levels of beryllium-7 concentrations were consistent for each sampling period at onsite, boundary, and distant locations.

Radiochemical Results

Transuranic radionuclides were not detected on annual filter composites using radiochemical analysis techniques.

Strontium-90 was measured at several monitoring locations, but the concentrations observed were well below levels that would pose a risk to human health.

Air Monitoring - Atmospheric Moisture and Precipitation

Monitoring Network and Instrumentation

In 2002, the INEEL OP operated 11 atmospheric moisture sampling stations strategically located on and around the INEEL. At all 11 locations, air samplers containing cartridges filled with molecular sieve beads (a desiccant) were co-located with the TSP air monitoring stations. The beads adsorb and retain moisture from air drawn through the cartridges by a pump.

Additionally, six of the eleven atmospheric moisture-sampling stations are equipped to collect precipitation.

Sample Collection Methods and Analysis

The molecular sieve beads were collected and processed at the end of each quarter, or when the beads had almost reached saturation, whichever occurred first. Moisture removed from the beads was analyzed for tritium, a radioactive isotope of hydrogen. Precipitation was collected quarterly or sooner if the container became full, and was analyzed for tritium and gamma-emitting radionuclides.

Results, Trends, and Interprogram Comparisons

Tritium

Tritium was detected in atmospheric moisture samples at two onsite monitoring locations, the Experimental Field Station and Van Buren. The tritium concentrations observed onsite are significantly below levels that would pose a risk to human health.

Each program follows slightly different protocols for monitoring extremely low concentrations of tritium in the atmosphere, including the use of different adsorbents, different sampling periods, and other interprogram variables that complicate direct comparisons between programs. The INEEL OP and BBWI atmospheric tritium monitoring results demonstrated very good agreement. Variations between INEEL OP and ESER atmospheric monitoring results demonstrated poor agreement due to differences in adsorbent media, analytical techniques, and sampling schedules used by individual monitoring programs. While there are differences in results, the measurements

observed were well below levels that would pose a risk to human health. No tritium was observed in INEEL OP precipitation samples collected in 2002.

Gamma-Emitting Radionuclide Results

Precipitation samples collected during 2002 did not show measurable concentrations of man-made, gamma-emitting radionuclides, as has been the case since 1994, when the INEEL OP began collecting precipitation.

Terrestrial Monitoring

Monitoring Network and Instrumentation

Milk was collected monthly at four processing plants in southeastern Idaho and the Magic Valley. These plants processed milk from dairies located both near and distant from the INEEL boundary.

Soil samples were collected from seven locations on the INEEL as well as at eight boundary and distant locations. *In-situ* soil measurements were also made at 54 locations on the INEEL as well as at boundary and distant locations.

Sample Collection Methods and Analysis

Milk samples were collected from fresh dairy shipments and analyzed using standard gamma spectroscopic methods. Iodine-131 and naturally occurring potassium-40 activity results are always reported, while other gamma-emitters are reported only if detection limits are exceeded.

Soil samples were collected from undisturbed locations near radiation monitoring stations at two depths, 0-5 cm and 5-10 cm, and analyzed with gamma spectroscopy. In addition, the concentrations of radionuclides in soil were measured *in-situ* (i.e., directly in the field) reducing the number of areas of soil that are disturbed by physically collecting a sample. Radionuclide concentrations measured *in-situ* are determined using an intrinsic, high-purity germanium detector assuming the distribution of radionuclides in the soil was homogenous throughout a soil depth of 0 to 5 cm.

Results, Trends, and Interprogram Comparisons

Naturally occurring potassium-40 was the only radionuclide detected in milk samples. Levels were consistent with concentrations measured by the INEEL OP in the past. The reported concentrations of iodine-131 have been less than the minimum detectable concentration since the inception of milk sampling in 1996. Likewise the ESER milk monitoring program, which collects from the same processing plants as well as some private dairies, did not detect iodine-131 over this same period.

INEEL OP conducted seven *in-situ soil* measurements with BBWI in 2002 for comparison purposes. Some differences were expected between gamma spectroscopic results due to analytical differences, but the cesium-137 concentrations reported by BBWI and INEEL OP correlated relatively well. During 2002, the INEEL OP collected ten soil samples with ESER. Results for cesium-137 concentrations demonstrated poor agreement, while the potassium-40 concentrations demonstrated relatively good agreement.

Water Monitoring

The INEEL OP water monitoring is divided into two programs distinguished by the primary purpose of the sampling; surveillance water monitoring and verification water monitoring. While both water sampling programs involve co-sampling with other INEEL monitoring programs, surveillance monitoring is designed to allow identification of trends in specific contaminants as well as INEEL impacts of overall groundwater quality. Samples are collected for the same analytes at all surveillance sites, unless gross radioactivity screening analyses indicate the presence of other INEEL contaminants. Verification monitoring collects samples for selected analytes based on permit, Record Of Decision, or investigation-derived requirements. Both sampling programs yield sample results that can be compared with that of the primary sampling programs.

Monitoring Network and Instrumentation

The INEEL OP monitors water quality at 78 locations: 28 groundwater and surface water sites on and around the INEEL, 5 drinking water sites and springs distant from the INEEL, and 45 groundwater sites and springs in the Magic Valley. INEEL OP also co-samples with the DOE's primary contractor, the monitoring group at ANL-W, and NRF at 33 locations on the INEEL.

Sample Collection Methods and Analysis

Water samples are collected and analyzed not only to detect contaminants known to have been disposed at INEEL facilities, but also to compare with and supplement INEEL data and provide information on general water quality. Water samples are collected following established procedures, and with methods comparable with those used by ANL-W, NRF, BBWI, USGS, and ESER. Samples collected for surveillance monitoring are analyzed for select trace metals, common ions, and nutrients that track constituents reported in wastes disposed to the aquifer beneath the INEEL. This same selection of nonradiological analytes also gives a picture of overall groundwater quality for the aquifer beneath the Eastern Snake River Plain. Gross radiological screening measures, gross alpha and gross beta radioactivity, gamma radioactivity, and tritium provide measures of background concentrations and INEEL waste disposal-related levels. Analytes for verification monitoring reflect regulation or agreement-required analytes based on historic waste disposal or contamination.

Results, Trends, and Interprogram Comparisons

Nonradiological Constituents

Calcium, chloride, magnesium, potassium, sodium, sulfate, total nitrogen and total phosphorus are known INEEL waste constituents that were detected above background levels in 2002 at some wells within known contamination plumes on the INEEL. However, none of the samples collected by the INEEL OP since 1994 exceeded the drinking water standards for these constituents.

Trace metals, barium, chromium, lead, manganese, and zinc were detected above background levels in samples collected within known groundwater contaminant plumes on the INEEL. Only chromium exceeded the maximum contaminant level (MCL) for drinking water, and only at one well that is not used for drinking water. Barium was detected above background at wells near the Idaho Nuclear Technology and Engineering Center (INTEC) and the Central Facilities Area (CFA). Chromium was above background levels in several wells on the INEEL due to historic wastewater disposal at the Test Reactor Area (TRA) and INTEC. Elevated levels of lead, manganese, and zinc may be attributable to well construction materials, existing natural concentrations in the environment, and INEEL activities. These findings are consistent with results reported by INEEL OP since 1994. During 2002, replicate samples for nonradiological constituent analysis were collected with the USGS at 26 groundwater and surface water locations on and near the INEEL, and at 17 locations in the Magic Valley. The INEEL OP and ESER co-sampled at three springs and two drinking water supply wells south of the INEEL and in the Magic Valley. INEEL OP and ESER sampled two additional locations, although not at the same date and time. Comparisons of nonradiological data reported by the INEEL OP and the USGS show excellent agreement for all replicate data.

The nonradiological results reported by the INEEL OP for the verification monitoring program were generally similar to the results reported by ANL-W, NRF, and the DOE's primary contractor at the INEEL. Replicate sample pairs for total phosphorus, aluminum, copper, nitrate + nitrite, sulfate, TKN, iron, zinc, trichloroethene, and total suspended solids failed the comparison criteria. Differences in results were generally attributed to sample heterogeneity and differences in analytical methods.

Radiological Constituents

Gross alpha screening measurements exceeded laboratory detection limits for samples collected at 23 locations during 2002. Gross alpha radioactivity measurements were well below the MCL for drinking water and within expected background levels.

Concentrations of gross beta radioactivity were detected above background in samples from all onsite wells except one. The highest concentrations were observed for two wells known to be impacted by INEEL wastewater. Radiochemical analyses of selected samples from these onsite wells indicate that strontium-90 is the primary source of the gross beta radioactivity. Although

strontium-90 exceeded the drinking water standard at one of these wells, the well is not used for drinking water.

Analyses were also conducted for gamma emitters and technetium-99. No gamma emitters were detected except for naturally occurring potassium-40 at six sites. Technetium-99, a fission product created in nuclear reactors, was detected in samples collected from four wells sampled on the INEEL.

Concentrations of tritium caused by historical waste-disposal practices were detected at levels near, but below, the drinking water standard at several INEEL wells. Overall, tritium concentrations appear to be decreasing within the identified plume at the INEEL. Elevated levels of tritium measured in wells at the Radioactive Waste Management Complex (RWMC) have remained fairly constant since INEEL OP began sampling. At offsite wells near the southern INEEL boundary, tritium has been detected at levels above background, but those levels are only about one percent of the drinking water standard.

The INEEL OP collected replicate samples in 2002 with the U.S. Geological Survey (USGS) on and near the INEEL, and south of the INEEL to the Snake River Canyon between Twin Falls and Hagerman. Replicate samples were also collected for the five locations where the INEEL OP co-samples with ESER in the Magic Valley. In addition, data for two additional locations where both INEEL OP and ESER collect samples were included in the comparisons. In general, the INEEL OP's radiological sample results showed good agreement with data reported by co-sampling organizations. Excellent agreement was noted for all nonradiological parameters. Although statistically significant differences were observed for gross alpha and gross beta radioactivity, these differences were relatively small compared to the concentrations observed. Data from co-sampled locations showing the greatest relative differences were strongly influenced by differences in analytical methods and sampling practices.

For the verification program, gross alpha, gross beta, and technetium-99 results did not meet the comparison criteria. The differences in the gross alpha and gross beta analyses are attributed to normal analytical variability or sample heterogeneity.

Environmental Radiation Monitoring

Monitoring Network and Instrumentation

In 2002, the INEEL OP maintained a network of 11 stations equipped with high-pressure ion chambers (HPICs), which continuously measure environmental penetrating radiation levels from natural cosmic and terrestrial sources, as well as from operations at the INEEL. Environmental radiation data collected at Fort Hall are also included. At each of the radiation monitoring stations, electret ion chambers (EICs) were also deployed to provide a cumulative total of radiation exposure at that location for the calendar quarter.

Measurement and Analysis

Penetrating radiation levels measured by the HPICs were compiled to provide daily, weekly, monthly, and quarterly average exposure rates. EICs were collected and processed quarterly.

Results, Trends, and Interprogram Comparisons

Cumulative radiation measurements from the HPICs were consistent with historical background levels measured by the INEEL OP. Because these instruments are not co-located with DOE-ID contractors, a comparison could not be made.

Penetrating radiation readings for the EICs were also consistent with historical background results. Although the results reported by the INEEL OP, BBWI, and ESER in 2002 fell within levels accepted as background, direct comparisons of the programs' results reflect interprogram variation due to different measurement schedules and monitoring techniques. Also, EICs used by INEEL OP are slightly more responsive to low-energy gamma and x-ray photons than the dosimeters used by other organizations and show slightly higher exposures from natural sources.

Chapter 1

Introduction

Oversight Program Mission and Environmental Surveillance Program

The mission of the state of Idaho's Idaho National Engineering and Environmental Laboratory Oversight Program (INEEL OP) is to provide the people of Idaho with independent, factual information about the INEEL, to help ensure the safety of the citizens of Idaho through the protection of public health and the environment, and to provide statewide radiological expertise. In partial fulfillment of this mission, the INEEL OP developed an Environmental Surveillance Program (ESP) with the following objectives:

- Maintain an independent environmental surveillance program designed to verify and supplement U.S. Department of Energy (DOE) surveillance programs.
- Provide the citizens of Idaho with information that has been independently evaluated to enable them to reach informed conclusions regarding the potential impacts of present and future DOE activities in Idaho.

This report documents the 2002 findings, developments, and conclusions of the INEEL OP ESP.

This annual report is intended to address the question: What is the impact of the INEEL on public health and the environment? The information provided herein represents the surveillance data resulting from environmental measurements made by the state of Idaho's INEEL OP on and around the INEEL during 2002.

The purpose of the INEEL OP ESP is to verify and selectively supplement surveillance information gathered by other surveillance programs, including the U.S. Geological Survey (USGS) and DOE-associated programs conducted by Bechtel BWXT Idaho, LLC (BBWI),

Argonne National Laboratory-West (ANL-W), Bechtel-Bettis Naval Reactors Facility (NRF), and the Environmental Surveillance Education and Research Program (ESER).

Each of these organizations performs monitoring tasks of defined scope; collectively, these programs gather data on a broad variety of media. To substantiate and augment the results reported by these surveillance programs, the INEEL OP measures external gamma radiation and samples air, precipitation, surface water, groundwater, verification sampling, soil, and milk at a number of strategically selected sites. The INEEL OP maintains monitoring locations separate from the other monitoring organizations to compile independent measurement results, conduct autonomous evaluations of results, and analyze data trends. Also, the INEEL OP collects environmental samples throughout the year at many of the same sites and when possible, at the same time as the other surveillance programs. The independence of both the primary and comparative results is preserved by the INEEL OP's contracting the analytical services of two laboratories not associated with any of DOE's surveillance programs: the Idaho State University Environmental Monitoring Laboratory (ISU EML) in Pocatello, and the State of Idaho Department of Health and Welfare Bureau of Laboratories in Boise (IBL).

The INEEL OP's annual findings, developments, and conclusions are presented in the following sections:

Environmental Surveillance Program Scope and Affiliations:

Section includes descriptive outline of the full scope of the INEEL OP's ESP, including monitoring locations, instrumentation, methodologies and interprogram relationships between the INEEL OP, DOE, and other organizations.

Air, Terrestrial, Water, Verification sampling, and Gamma Radiation Monitoring Results:

Section includes individual chapters containing the 2002 data for each media of the INEEL OP network; discussions of identifiable trends; comparisons of 2002 data to previously collected data; and comparisons of INEEL OP results to those reported by DOE and other surveillance programs.

Environmental Surveillance Program's Quality Assurance and Quality Control (QA/QC) Results:

Section includes summary of QA/QC activities for the year including any corrective actions identified and taken.

Conclusion and Plans for Future Work:

A summation of the program's critical findings.

Appendices:

Addenda on specific topics addressed in the preceding sections:

Appendix A--initial development and design of the INEEL OP ESP.

Appendix B--glossary of technical terms and units used in this report.

Analytical results are available in either electronic or printed format. They can be downloaded from the INEEL Oversight Program's website at: <http://www.oversight.state.id.us>T, or requested by contacting 1-800-232-4635, or:

State of Idaho
INEEL Oversight Program
900 N. Skyline, Suite C
Idaho Falls, ID 83402

Chapter 2

Environmental Surveillance Program Scope and Affiliations

INEEL Oversight Program Environmental Surveillance Program History and Legislative Authority

The INEEL OP was created when there was growing concern about environmental contamination from activities at DOE facilities. In the late 1980s, the U.S. Secretary of Energy proposed an oversight role for states hosting these DOE facilities. According to this proposal, states would receive funding and information that would enable them to independently assess environmental conditions and activities at DOE facilities. In 1989, the Idaho Legislature enacted Senate Bill 1266, establishing a comprehensive oversight program for the INEEL. In May 1990, the state and DOE signed a five-year Environmental Oversight and Monitoring Agreement. This agreement, which has subsequently been renewed for two additional, five-year periods, funded the state's INEEL OP and set forth the following responsibilities:

- Secure independent data and information regarding DOE activities in Idaho;
- Scientifically evaluate information on INEEL impacts to the public and environment; and
- Independently report conclusions to the people of Idaho.

The INEEL Oversight Program (INEEL OP)

The INEEL OP's environmental surveillance network on and around the INEEL generates data that can be used to verify and supplement the results reported by Bechtel Bettis, BBWI, ANL-W, and ESER, as well as results published by the USGS. Analysis results for 2003 are available in INEEL OP's quarterly reports.

The scope of the INEEL OP's network has expanded as goals and objectives for the program have evolved, as described in the history of the network's design and development provided in **Appendix A**.

Currently, the INEEL OP monitors multiple environmental media which have been or potentially could be contaminated by activities at the INEEL, including air, external gamma radiation, soil, milk, surface water, and groundwater.

Independent sampling is performed at selected locations. As summarized in **Table 2-1**, samples collected from these locations are routinely analyzed for a variety of constituents, and the analytical results compiled from this data form an independent base of scientific findings that can be used to verify results reported by DOE and other surveillance programs. Sampling frequency for some water monitoring sites was reduced beginning October 2001 due to a reduction of sampling frequency by the USGS. The USGS is relied on to provide equipment and logistics necessary to collect samples at these specific sites. To maintain the independent status of INEEL OP results, the INEEL OP contracts analytical services from two laboratories which are not associated with any of DOE's surveillance programs: the Idaho State University Environmental Monitoring Laboratory (ISU EML) in Pocatello, and the State of Idaho Department of Health and Welfare Bureau of Laboratories in Boise (IBL).

The ISU EML is the primary provider of radiological analytical services to the INEEL OP. Located in the Physics Department of the university, the laboratory performs analyses that include screening for gross alpha and gross beta radioactivity, gamma spectroscopy, liquid scintillation counting for tritium, and analysis for technetium-99 using Empore Selective Ion filter disks. Environmental samples requiring radiochemical analyses or other specific analyses are contracted out to other laboratories by the ISU EML. The ISU EML is also involved in other aspects of the INEEL OP ESP, including conducting applied research, providing technical guidance, assisting with program design, and providing student interns who participate in field sampling and data analysis.

The IBL is the primary provider for the non-radiological analyses of INEEL OP surface water and groundwater samples. For these samples, the laboratory supplies results on a suite of nonradiological analytes, including common ions, trace metals, nutrients, and volatile organic compounds (VOCs).

Each laboratory maintains an internal quality control program to ensure consistency and accuracy, and to provide a means of assessing the quality of the data reported. Should a laboratory

note a concern that could potentially affect the quality of the data or during review by INEEL OP, the INEEL OP may assign a data qualifier to the analytical results for a particular sample, depending on the severity of the problem. During data validation by the INEEL OP, an analytical result may be rejected or accepted as an estimate, in accordance with protocols developed by the EPA.

Table 2-1. INEEL OP Environmental Surveillance Program (ESP) summary, 2002

TABLE 2.7. TABLE OF Environmental Surveillance Program (ESP) Summary, 2002

| Media Sampled Type of Analysis | | Number of Air Locations and Frequency ^a | | | Minimum Detectable Quantities |
|--|--|---|------------------|------------------|-----------------------------------|
| | | Onsite | Boundary | Offsite | |
| Air | | | | | |
| Dry Particulate (PM ₁₀ Samplers) | | | | | |
| | Alpha | - | 2 W | 1 W | 0.001 pCi/m ³ |
| | Beta | - | 2 W | 1 W | 0.001 pCi/m ³ |
| | Gamma | - | 2 Q ^b | 1 Q ^b | 0.003 pCi/m ³ (Cs-137) |
| | Radiochemical ^c | - | 2 A ^b | 1 A ^b | Varies |
| Dry Particulate (TSP Samplers) | | | | | |
| | Alpha | 4W | 4W | 3W | 0.001 pCi/m ³ |
| | Beta | 4W | 4W | 3W | 0.001 pCi/m ³ |
| | Gamma | 4Q ^b | 4Q ^b | 3Q ^b | 0.002 pCi/m ³ (Cs-137) |
| | Radiochemical ^c | 4 A ^b | 4 A ^b | 3 A ^b | Varies |
| Gaseous | Iodine-131 | 4 W | 4 W | 3 W | 0.006 pCi/m ³ |
| Atmospheric Moisture | | | | | |
| | Tritium | 4 Q | 4 Q | 3 Q | 1 pCi/m ³ |
| Precipitation | | | | | |
| | Tritium | 1 Q | 4 Q | 1 Q | 160 pCi/L |
| | Gamma | 1 Q | 4 Q | 1 Q | 6 pCi/L (Cs-137) |
| Direct Radiation | | | | | |
| Gamma (High-Pressurized Ion Chambers (HPIC)) | | | | | |
| | Gamma (μR/hr) (continuous readings) | 5 | 5 | 2 | 1.4 μR/hr |
| Environmental Dosimeters (EIC) ^g | | | | | |
| | | 7Q | 4Q | 3Q | 10 mR per quarter |

Table 2-1 continued. INEEL OP Environmental Surveillance Program (ESP) summary, 2002

| Media Sampled Type of Analysis | Number of Air Locations and Frequency ^a | | | Minimum Detectable Quantities |
|---|---|-----------------------|-----------------|---|
| | Onsite | Boundary | Offsite | |
| Milk | | | | |
| Gamma Spectroscopy ^f Iodine-131 | | | 5 M (2M) | 4 pCi/L (I-131) |
| Soil | | | | |
| Gamma Spectroscopy ^d | 13 A | 4 A | 1 A | 0.01 pCi/g (Cs-137) |
| Water: Radiological | | | | |
| Alpha | 33 Q/S ^e | 13 Q/S ^{e,f} | 5 Q, 18 of 55 T | 2-5 pCi/L |
| Beta | 33 Q/S ^e | 13 Q/S ^{e,f} | 5 Q, 18 of 55 T | 2-3 pCi/L |
| Gamma | 33 Q/S ^e | 13 Q/S ^{e,f} | 5 Q, 18 of 55 T | 6-10 pCi/L (Cs-137) |
| Tritium | 23 Q/S ^e | 13 Q/S ^{e,f} | 5 Q, 18 of 55 T | 160 pCi/L (15-20 pCi/L for electrolytically enriched) |
| Sr-90 | 11 S ^e | | | 3-4 pCi/L |
| Tc-99 | 4 S ^e | | | 4-5 pCi/L |
| Water: Non-radiological | | | | |
| Common Ions | | | | |
| Total Alkalinity | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 1.0 mg/L |
| Calcium | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 0.1 mg/L |
| Chloride | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 2.0 mg/L |
| Fluoride | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 0.1 mg/L |
| Magnesium | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 0.05 mg/L |
| Potassium | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 0.1 mg/L |
| Sodium | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 0.1 mg/L |
| Sulfate | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 2-4.5 mg/L |
| Nutrients | | | | |
| Nitrate + Nitrite as Nitrogen | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 0.005 mg/L |
| Nitrogen (ammonia) | 23 A | | | 0.005 mg/L |
| Nitrogen (Kjeldahl) | 23 A | | | 0.05 mg/L |
| Phosphorus | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 0.05 mg/L |
| Trace Metals | | | | |
| Aluminum | 23 A | | | 50 µg/L |

Table 2-1 continued. INEEL OP Environmental Surveillance Program (ESP) summary, 2002

| Media Sampled Type of Analysis | Number of Air Locations and Frequency ^a | | | Minimum Detectable Quantities |
|-----------------------------------|---|-----------------------|---------|-------------------------------------|
| | Onsite | Boundary | Offsite | |
| Antimony | 23 A | | | 5 µg/L |
| Arsenic | 23 A | | | 10 µg/L |
| Barium | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 1 µg/L |
| Beryllium | 23 A | | | 1 µg/L |
| Cadmium | 23 A | | | 100 µg/L |
| Chromium | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 2 µg/L |
| Cobalt | 23 A | | | 5 µg/L |
| Copper | 23 A | | | 10 µg/L |
| Iron | 23 A | | | 10-20 µg/L |
| Lead | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 5 µg/L |
| Manganese | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 10 µg/L |
| Mercury | 23 A | | | 0.5 µg/L |
| Nickel | 23 A | | | 10 µg/L |
| Selenium | 23 A | | | 5 µg/L |
| Silver | 23 A | | | 1 µg/L |
| Thallium | 23 A | | | 1.5 µg/L |
| Vanadium | 23 A | | | 10 µg/L |
| Zinc | 15 Q/S ^e 23 A | 13 Q/S ^{e,f} | 5 A | 5 µg/L |
| Volatile Organic Compounds | 5 A | | | 0.5 µg/L |

^a Sample frequency: W – weekly, M – monthly, Q – quarterly, S – semiannually, A – annually, T – triennially
^b Quarterly and annual analyses performed on composited weekly samples for each location.
^c Radiochemical analyses include Pu-238, Pu-239/240, Am-241, and Sr-90.
^d Gamma spectroscopy of soil samples includes examination of the spectra specifically for the man-made gamma-emitters Cs-137 and Co-60 and the naturally occurring gamma-emitters Bi-214, Pb-214, and Ac-228. Other radionuclides occurring above the detection limit will be identified by the analysis software.
^e Quarterly and semi-annual sampling schedules with varied frequencies. Includes three surface water sites.
^f Does not include two co-sampling locations with ESER, selected on a random basis.

Other Surveillance Programs

Bechtel BWXT Idaho, LLC (BBWI)

As the INEEL operating contractor for the DOE, BBWI is responsible for collecting and analyzing radiological and nonradiological samples for the Site Environmental Surveillance Program. BBWI conducts onsite monitoring of air, ground and surface water, soil, and vegetation, with some limited offsite sampling for comparative purposes. BBWI utilized the RML for 2002.

The S.M. Stoller Corporation (ESER)

S.M. Stoller Corporation operates the offsite monitoring for DOE under the Environmental Surveillance Education and Research (ESER) contract. ESER also performs some limited onsite

monitoring. Currently, ESER results applicable to interagency comparisons include those for samples collected from the air and external radiation measurements, and samples of ground and surface water, soil, and milk. In an effort to maintain independence, ESER employs the services of the ISU Environmental Assessment Laboratory (ISU EAL), which is separate from the ISU EML, for radiological analyses, and contracts with an outside laboratory for radiochemical analyses.

United States Geological Survey (USGS)

As part of the long-term collection of hydrological and geological data related to the presence and movement of radioactive and nonradioactive constituents in groundwater, the USGS conducts ground and surface water monitoring both on and off the INEEL. Samples collected by the USGS on and near the INEEL are analyzed by the DOE Radiological and Environmental Sciences Laboratory (RESL), and by the USGS National Water Quality Laboratory in Arvada, Colorado. Analytical results are presented in USGS reports.

Argonne National Laboratory (ANL-W)

The University of Chicago operates Argonne National Laboratory, with facilities in Illinois (ANL-E) and Idaho (ANL-W), for DOE. As a separate organization from BBWI, ANL-W operates its own environmental sampling program, and contracts with outside laboratories for analyses.

Naval Reactors Facility

Naval Reactors Facility (NRF) is operated for the Naval Nuclear Propulsion Program, United States Department of Energy, Naval Reactors, by Bechtel Bettis, Inc. As a separate organization from BBWI, NRF operates its own environmental sampling program, and contracts with an outside laboratory for analyses.

Shoshone-Bannock Tribes

The Shoshone-Bannock Tribes operate a community air monitoring station at Fort Hall similar in design and complement of instruments to the INEEL OP community monitoring stations. These samples are also analyzed by the ISU EML.

The INEEL OP Sampling Network and Co-Sampling Strategies

Air Monitoring

Air samples collected by the INEEL OP in 2002 were screened for gross alpha and gross beta radioactivity, and gamma radioactivity, and analyzed for tritium in atmospheric moisture.

Radiochemical analyses were performed on composited air filters for strontium-90, plutonium-238 and -239/240, and americium-241. Typically, the INEEL OP reports all results for gross alpha and beta radioactivity, but notes only those gamma spectroscopy results exceeding the minimum detectable concentration (MDC). As part of gamma spectroscopic analyses, specific results are reported by the laboratory for ruthenium/ rhodium-106, antimony-125, cesium-134, and cesium-137.

Air Monitoring Locations

Extensive studies of the complex wind patterns of the Eastern Snake River Plain strongly influenced the placement of the stations in the original INEEL OP air monitoring network. From an initial six monitoring sites in 1992, the INEEL OP Environmental Surveillance Program (ESP) has expanded to include the ten air monitoring stations identified in **Figure 2-1**. Currently, each of these stations is equipped with instruments to collect airborne particulate matter, gaseous radioiodine, and water vapor. Six stations are equipped to collect precipitation. The INEEL OP also reports air monitoring data for samples collected at a station in Fort Hall operated by the Shoshone-Bannock Tribes.

Each monitoring station is categorized by location as onsite, boundary, or distant. **Table 2-2** lists the sample types, frequency, and analyses conducted by the INEEL OP for each location, and also identifies the comparable schedule and analysis activities for other agencies sampling at each location.

Air Monitoring Equipment and Procedures

Air Samplers

During 2002, particulate air sampling was conducted using both intermediate-flow PM₁₀ samplers (particulate matter with aerodynamic diameters of 10-μm and less) and high-volume total suspended particulate (TSP) samplers operated continuously. Samples are collected on 10-cm (4-inch) diameter membrane filters. Filters are weighed to the nearest 0.0001-g prior to deployment. Filters are collected weekly, stored for approximately five days in a desiccator to remove excess moisture from the filters and weighed to determine particulate mass concentrations. Also, the filters are stored for five days to allow the radioactive decay of short-lived radon progeny prior to gross alpha and gross beta screening analyses.

Since January 2001, the two sampling systems were operated side-by-side in an effort to identify a replacement for the aging PM₁₀ samplers. During 2002, the TSP samplers operated much more consistently than did the PM₁₀ samplers. This fact coupled with better similarity between mass loading observed by DOE-ID contractors using low-volume TSP samplers offered a stronger opportunity for INEEL OP to validate or verify DOE-ID air monitoring efforts. Since this was the case, the TSP samplers have been adopted as the primary particulate air samplers used by INEEL OP. Three PM₁₀ samplers

remain in operation to validate TSP sampling data at two boundary locations and one distant location.

Radioiodine (iodine-131) is collected using an activated charcoal adsorbent. The charcoal canister is placed directly behind the membrane filter of the PM₁₀ sampler. The canisters are collected weekly and analyzed via gamma spectroscopy for iodine-131 within 24-hours of collection. The methodology for sampling for radioiodines will be updated during 2003 to eventually phase out the use of the PM₁₀ samplers at all but three of the monitoring locations.

To obtain additional data for the evaluation of trends in air quality, the INEEL OP has incorporated annual radiochemical analyses of the particulate air filters. From 1996 to the present, the particulate filters have been composited annually by location and sent to a commercial laboratory for radiochemical analyses of strontium-90, plutonium-238, plutonium 239/240, and americium-241.

Precipitation Samplers

Six of the INEEL OP air monitoring stations are equipped to collect precipitation samples for radiological analyses, as shown in **Table 2-2**. The precipitation is collected on a one-meter square, metal tray attached to a polyethylene collection vessel. At the end of each quarter or when the collection vessel is nearly full, whichever occurs first, the precipitation samples are collected, composited by quarter if necessary, and analyzed for tritium and gamma-emitting radionuclides.

Atmospheric Moisture Samplers

Atmospheric moisture is collected at 11 of the monitoring stations by passing air through a column containing a desiccant (molecular sieve) that removes and stores moisture from the air. As indicated in **Table 2-2**, the samples are collected when the column nearly reaches saturation or at the end of each quarter, whichever occurs first. Heating the desiccant releases the moisture, that is collected as condensation and analyzed for tritium.

Interprogram Air Sampling Results and Comparisons

As indicated in **Figure 2-1**, INEEL OP, BBWI, and ESER conducted co-located sampling activities throughout 2002, with each organization separately performing the range of scheduled analyses identified. In this report, the results of INEEL OP measurements are compared directly to those of the two DOE monitoring programs.

Each organization performing air sampling as part of its respective surveillance program collects airborne particulate matter, but collection equipment varies slightly. The INEEL OP uses high-volume TSP samplers and intermediate flow PM₁₀; ESER and BBWI use low-volume particulate air samplers.

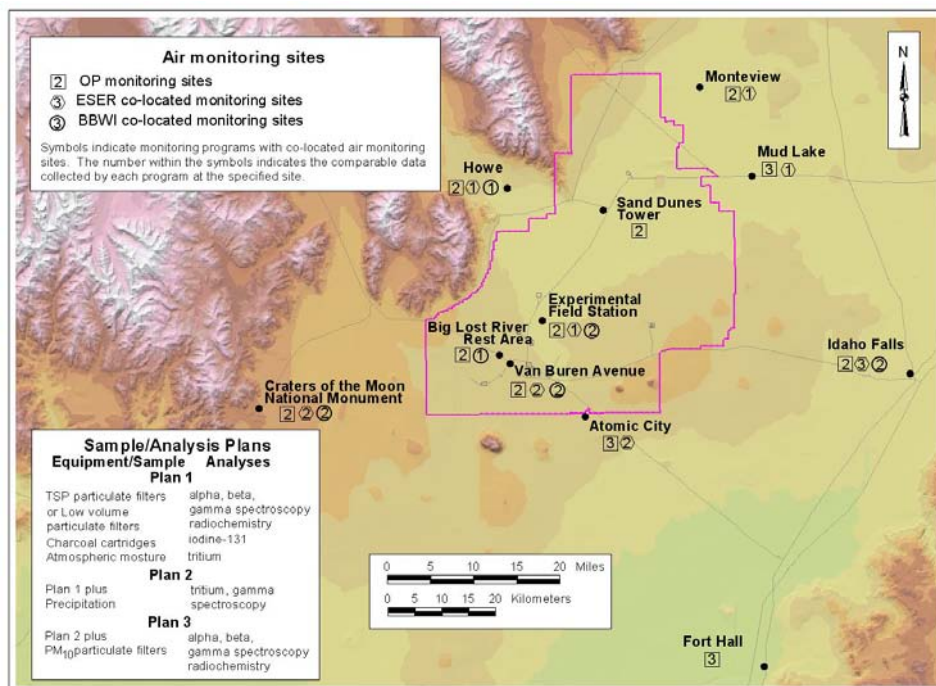


Figure 2-1. Air monitoring locations.

Each agency performing air sampling conducts gross alpha and gross beta radioactivity screening analyses, gamma spectroscopic analyses of composite filter samples, and radiochemical analyses of composite filter samples, although radiochemical analyses are done on different schedules on samples from different locations by the various organizations. Each group collects iodine-131 samples using activated charcoal cartridges that are analyzed by gamma spectroscopy.

The sampling schedules, analyses, and instruments used by the participating agencies are listed in **Table 2-2**. The INEEL OP and BBWI each collected particulate, radioiodine, and composite atmospheric moisture samples at three identical or nearby locations. Similarly, INEEL OP and ESER collected particulate, radioiodine, and composite atmospheric moisture samples at three identical or nearby locations.

Linear regressions, Quantile-Quantile plots, and paired t-tests were the primary statistical tools used to compare the gross alpha, gross beta, and gamma spectroscopy results from these locations.

Table 2-2. Interprogram air monitoring sampling/analyses schedules, 2002

| Co-located Sampling Instrumentation, Scheduling, and Analyses | | | | |
|---|--|-------------------------------|------------------------------|------------------------------|
| Equipment/Sample Types | Particulate Air Sampling | Charcoal Cartridges | Atmospheric Moisture | Precipitation |
| Frequency of Sampling | Weekly | Weekly | Quarterly^e | Quarterly^f |
| Analyses^{a, b} | Alpha, Beta, Gamma Radiochemistry^d | Iodine-131^c | Tritium | Tritium, Gamma |
| Onsite Locations/Organization[*] | | | | |
| Experimental Field Station | OP ESER BB | OP ESER BB | OP ESER BB | ESER |
| Sand Dunes | OP | OP | OP | |
| Van Buren Avenue | OP ESER BB | OP ESER BB | OP BB | |
| Big Lost River Rest Area | OP | OP | OP | OP |
| Boundary Locations/Organization[*] | | | | |
| Atomic City | OP ESER | OP ESER | OP ESER | OP |
| Howe | OP ESER BB | OP ESER BB | OP | OP |
| Montevue | OP ESER | OP ESER | OP | OP |
| Mud Lake | OP ESER BB | OP ESER BB | OP | OP |
| Distant Locations/Organization[*] | | | | |
| Idaho Falls | OP ESER BB | OP ESER BB | OP ESER | OP ESER |
| Craters of the Moon | OP ESER BB | OP ESER BB | OP BB | |
| Fort Hall | SB | SB | OP | |
| [*] Sampling Organization Abbreviations: OP = INEEL OP ESER = Stoller BB = BBWI SB = Shoshone-Bannock Tribes ^a The INEEL OP samples the PM ₁₀ fraction of airborne particulate matter, as well as the total particulate matter; ESER and BBWI sample total particulate matter. ^b Identifies all INEEL OP analyses and those co-sampling agency analyses used for comparisons of results. ^c Samples composited by location and analyzed by gamma spectroscopy on different schedules. ^d Samples composited by location and analyzed by radiochemical techniques for plutonium-238, plutonium-239/240, americium-241, and strontium-90 on different schedules. ^e Samples are collected quarterly or when beads reach saturation. ^f Samples are collected quarterly or when sample container is full, whichever occurs first. | | | | |

Direct Radiation Monitoring

The INEEL OP uses a combination of instruments that measure the environmental radiation levels from natural cosmic and terrestrial sources as well as from possible contributions from operations at the INEEL. The INEEL OP can therefore report the results of measurements of both time-dependent exposure and time-integrated exposure to environmental gamma radiation.

Direct Radiation Monitoring Locations

Local climatology and atmospheric dispersion models for the INEEL influenced the selection of the locations for the initial radiation monitoring sites in much the same way that such modeling techniques facilitated the placement of the air monitoring stations. Since 1995, the network has included the 14 stations identified in **Figure 2-2**.

Direct Radiation Monitoring Equipment and Procedures

The direct radiation monitoring instrumentation located at each routine station is listed in **Table 2-3**, and additional EIC locations can be found in **Figure 7-2**. The majority of the gamma radiation stations are co-located with air monitoring sites.

Electret Ion Chambers

Electret Ion Chambers (EIC) are deployed at radiation monitoring stations to measure cumulative exposure to penetrating radiation in milliRoentgens (mR). The EICs are deployed at 91 monitoring locations on the INEEL, near the INEEL boundary, and at distant locations. Of these 91 locations, there are 68 monitoring locations on the INEEL along highways, access roads, and at INEEL facilities. Of the 23 monitoring locations, 11 are located at boundary locations and 12 distant locations. Average exposure rates in microRoentgens per hour ($\mu\text{R/hr}$) are reported using the cumulative exposure divided by the deployment time. The EICs are constructed from carbon-filled polypropylene that offers a nearly air-equivalent response. Before deployment, each EIC's initial voltage is read and recorded. The EIC is then packaged in a mylar plastic bag which is heat sealed. After being labeled, the bag is placed in a tyvek envelope for protection from the elements. At the end of each calendar quarter, the exposed environmental dosimeters are collected, final voltages are read and recorded, and gamma radiation exposures are calculated.

High-Pressure Ion Chambers (HPICs)

At the 11 monitoring sites identified in **Table 2-3**, high-pressure ion chambers (HPICs) continuously measure the gamma radiation exposure rate in microRoentgens per hour ($\mu\text{R/hr}$). INEEL OP also uses the data from the HPIC at Fort Hall operated by the Shoshone-Bannock Tribes shown in **Figure 2-2**. Exposure rates are measured every five seconds, and then averaged over five-minute intervals by the data system associated with each HPIC. Each station is equipped with data loggers, as well as a radio telemetry system for transmitting the five-minute values to the INEEL OP Idaho Falls office.

Table 2-3. Direct radiation monitoring locations, 2002

| Instrumentation: | Environmental Dosimeter (EIC) | High-Pressurized Ion Chamber (HPIC) |
|----------------------------|-------------------------------|-------------------------------------|
| Analysis | Gamma ($\mu\text{R/hr}$) | Gamma ($\mu\text{R/hr}$) |
| Onsite Locations | | |
| Base of Howe Peak | ♦ | ♦ |
| Big Lost River Rest Area | ♦ | ♦ |
| Experimental Field Station | ♦ | |
| Main Gate | ♦ | ♦ |
| Rover | ♦ | ♦ |
| Sand Dunes | ♦ | ♦ |
| Van Buren Ave. | ♦ | |
| Boundary Locations | | |
| Atomic City | ♦ | ♦ |
| Big Southern Butte | ♦ | ♦ |
| Howe Met Tower | ♦ | ♦ |
| Montevue | ♦ | ♦ |
| Mud Lake | ♦ | ♦ |
| Distant Locations | | |
| Idaho Falls | ♦ | ♦ |
| Craters of the Moon | ♦ | |

Interprogram Direct Radiation Monitoring Results and Comparisons

During 2002, the DOE and the INEEL OP did not co-locate HPICs for direct radiation measurement. However, the INEEL OP co-located EICs with a limited number of thermoluminescent dosimeters (TLD) from the other surveillance programs.

Terrestrial Monitoring

Terrestrial environmental surveillance typically includes examination of several mechanisms that tend to collect and/or accumulate radioactive material in the environment. Such mechanisms include the concentration of important nutrients and minerals by cattle. Cows' milk tends to concentrate iodine, and since cows typically graze over large areas of pasture, radioiodine fallout may be detected in milk at concentrations corresponding to relatively low concentrations in the environment.

The INEEL OP also conducts *in-situ* soil measurements for selected naturally occurring and man-made, gamma-emitting radionuclides. The locations for soil and milk sampling reflect the consideration of potential source terms, their significance, regional meteorology, and monitoring activities by other programs.

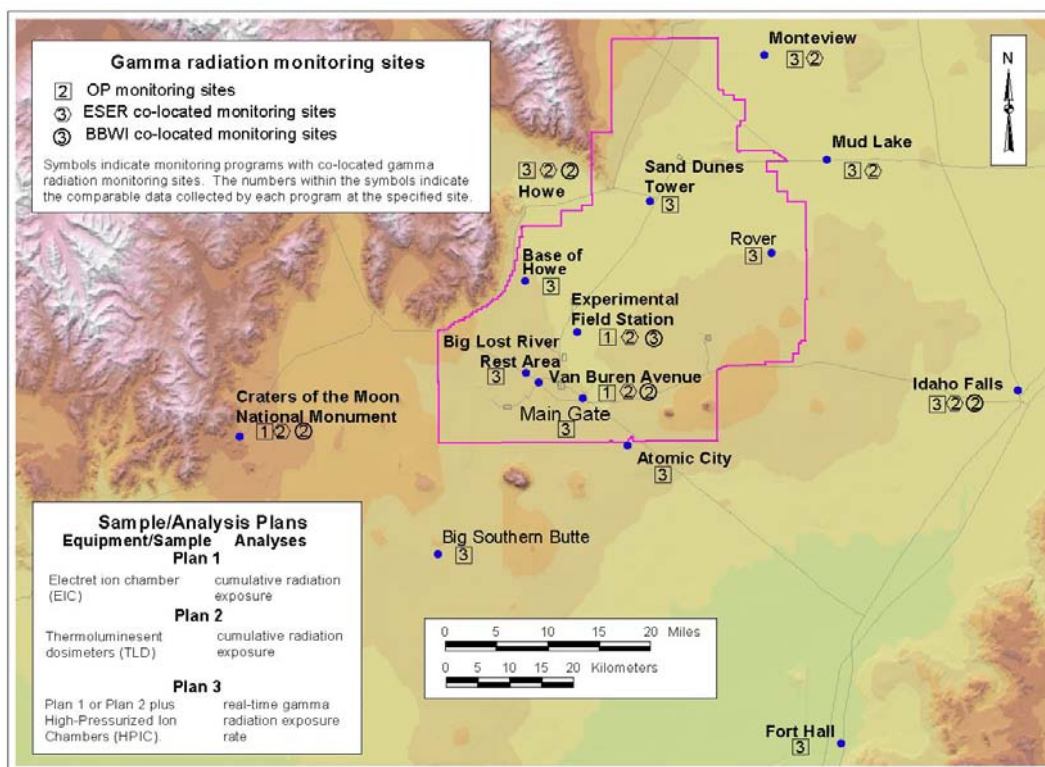


Figure 2-2. Gamma Radiation Monitoring.

Terrestrial Monitoring Locations

Milk Sample Collection Sites and Dairy Locations

Milk samples were collected from four processing plants in Rexburg, Pocatello, Rupert and Gooding. Each plant processes milk produced by dairies in other localities. For example, the Rexburg plant receives milk originally from dairies in the Howe and Mud Lake areas. In addition, the INEEL OP analyzes two samples per quarter that are collected by ESER for verification purposes.

Soil Monitoring Locations

Annually, soil is monitored at INEEL OP's routine air monitoring locations. Performing these measurements at permanent monitoring sites allows the INEEL OP to evaluate the terrestrial component of gamma radiation measurements. In addition, soil measurements are performed at sites co-located with the DOE contractor to verify their analytical results. For 2002, soil was monitored at seven locations, and *in-situ* measurements were made at 55 locations **Figure 2-4**.

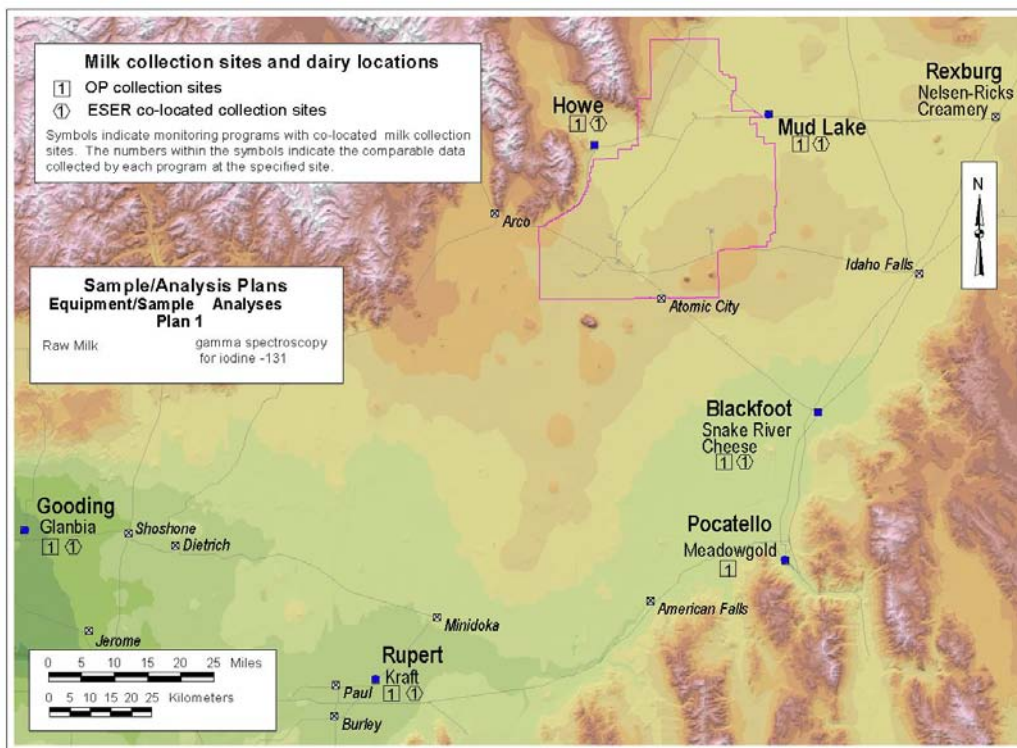


Figure 2-3. Milk Monitoring Locations

Terrestrial Monitoring Equipment and Procedures

Milk Monitoring

Monthly milk samples are collected from fresh dairy shipments after receipt at the processing plants. Two-liter composite samples are collected from each of the four offsite distribution locations, as well as two samples collected by ESER. These samples are analyzed by gamma spectroscopy within seven days of collection.

Soil Monitoring

Rather than disturb the soil by physically collecting a sample, the concentration of radionuclides in the soil was measured *in-situ*. Radionuclide concentrations were determined using an intrinsic, high-purity germanium detector assuming the distribution of radionuclides in the soil are homogenous throughout a depth of 0 to 5 cm.

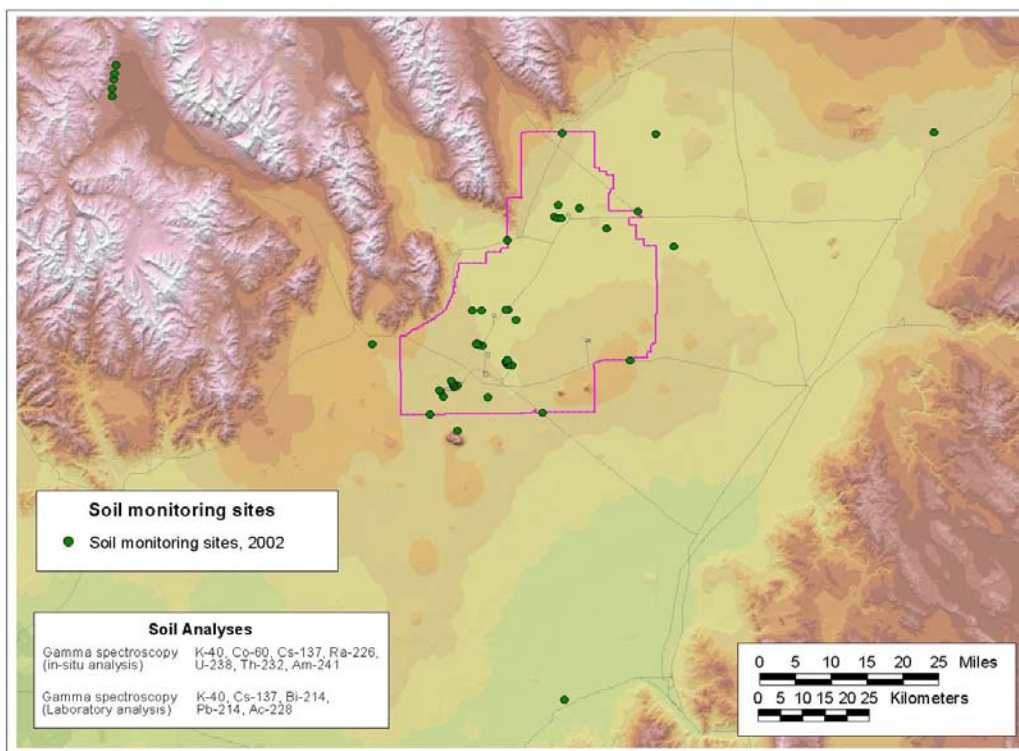


Figure 2-4. Soil Monitoring Locations

Interprogram Terrestrial Monitoring Results and Comparisons

The INEEL OP collects milk samples after delivery to the distribution centers; currently, ESER collects milk samples from farms prior to shipment. Two milk samples were collected by ESER each month and submitted to INEEL OP for independent gamma-spectroscopic analysis. These are used for verification (co-sampling) purposes.

Water Monitoring

The analyses of water samples collected by the INEEL OP primarily measure concentrations of contaminants known to have been released as liquid effluents from INEEL facilities, but also measure analytes that characterize general water chemistry. Nonradiological analyses are performed for common ions, nutrients, and selected trace metals. Radiological samples undergo analyses for alpha and beta radioactivity, gamma-emitting radionuclides, tritium, strontium-90, technetium-99, uranium and americium-241.

Although very few of the wells sampled by the INEEL OP supply drinking water systems, all analytical results are compared to the EPA's maximum contaminant levels (MCL) or secondary maximum contaminant levels (SMCL). A contaminant's MCL defines the maximum permissible

level of that contaminant allowed in a community water system. Concentrations in excess of the MCL may result in adverse impacts to human health or unacceptable risk levels.

A contaminant's SMCL identifies the maximum level at which the contaminant can be measured before the aesthetic qualities of the water are impacted. Although the SMCL is not a legally enforceable limit, concentrations of contaminants that exceed SMCLs may adversely affect the odor, taste, or appearance of water.

The Eastern Snake River Plain Aquifer has been designated as a "sole source" aquifer by the EPA, supplying the majority of drinking water for many Idahoans. Comparing analytical results of water samples taken from the aquifer with MCLs and SMCLs provides a useful means of determining if the quality of this very important source of water is at risk.

Starting in 1999, INEEL OP initiated a verification portion to the water monitoring program in which wastewater and groundwater locations on the INEEL were co-sampled with BBWI, ANL-W, or NRF for direct comparison purposes. Nonradiological analyses are performed for common ions, nutrients, trace metals, and volatile organic compounds (VOCs). Radiological samples undergo analyses for alpha and beta radioactivity, gamma-emitting radionuclides, tritium, strontium-90, plutonium isotopes, uranium isotopes, neptunium-237, and technetium-99.

Water Monitoring Locations

The INEEL OP monitors water quality at 78 locations for surveillance sampling and 33 locations for verification. Sampling locations are shown in **Figures 2-5**, and **2-6**. Sampling sites are grouped by location and type with the following categories: onsite, boundary, distant, Magic Valley, and surface. **Table 2-4** specifies the routine sampling schedules, analyses, and corresponding co-sampling organizations for each of these locations. Wastewater and groundwater verification samples were collected with BBWI, NRF, and ANL-W at several locations on the INEEL (**Figure 2-7**). **Table 2-5** presents the verification sampling program's water monitoring schedules and analyses for each location.

Beginning in October 2001, the USGS reduced sampling frequency for most water monitoring sites on the INEEL, resulting in a reduction in the number of water surveillance samples collected by the INEEL OP. Sites sampled quarterly on the INEEL by the USGS were reduced to semi-annual sampling. A selected number of sites sampled semi-annually prior to October 2001 were reduced to annual sampling. The INEEL OP adjusted its sampling schedule to correspond to USGS sampling frequency, with the exception of Atomic City, where a quarterly sampling schedule was maintained. Sample locations and frequency are summarized in **Table 2-4**. With 2002 sampling, ten locations were dropped from the Magic Valley sampling program. These sites were located very near other Magic Valley sample locations and yielded similar results. Site accessibility was also a factor in the decision to remove the selected sites from active monitoring. These sites may be used as alternate sample locations in the future.

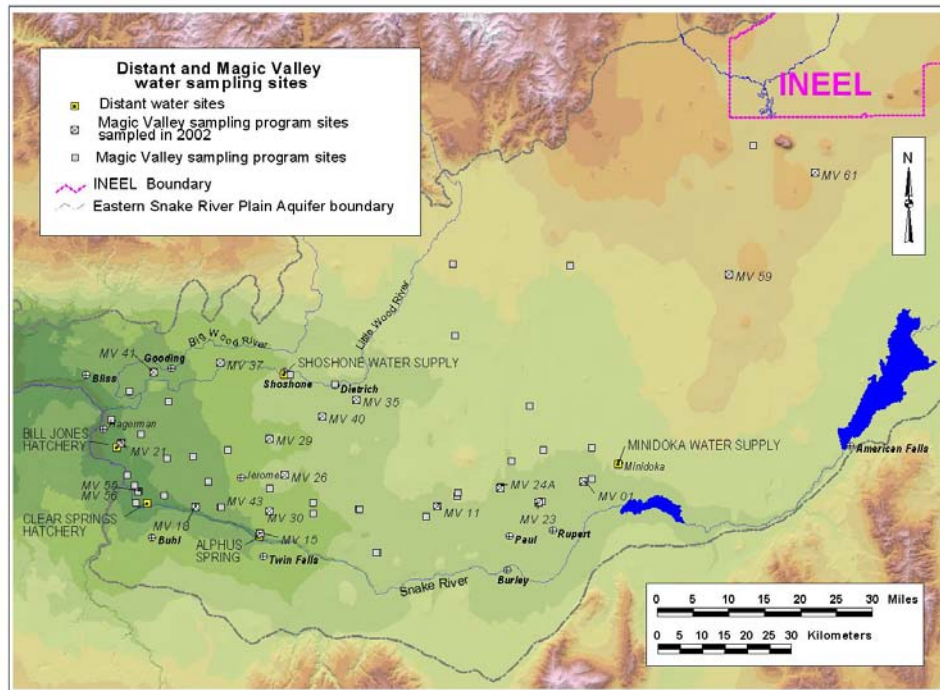


Figure 2-6. Distant and Magic Valley Water Sampling Locations (make 2002)

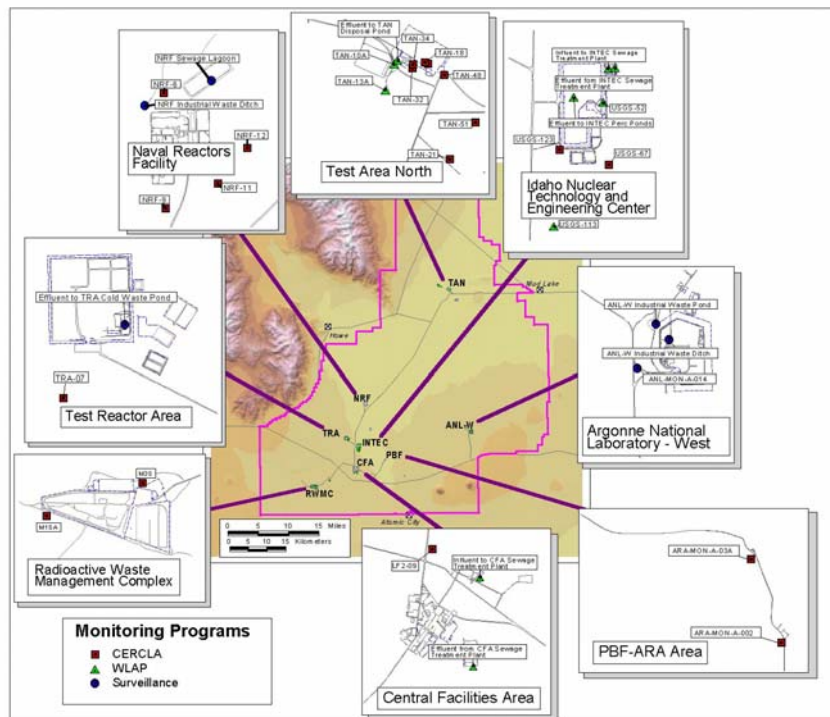


Figure 2-7. Water Verification Monitoring Sites

Table 2-4. Interprogram water monitoring sampling schedules and analyses, 2002

| Co-located/Replicate Sample Analyses | | Radiological | | Nonradiological | | |
|--------------------------------------|-------------|---|----------------------|----------------------|----------------------|------------------|
| Analysis | Frequency * | Gross Alpha, Gross Beta, Gamma Spectroscopy | Tritium | Metals | Common Ions | Nutrients |
| Onsite Locations | | Organizations | | | | |
| CFA 1 | S | OP | OP USGS | OP USGS | OP USGS | OP USGS |
| CFA 2 | S | OP | OP USGS | OP USGS | OP USGS | OP USGS |
| RWMC Production | S | OP | OP | OP | OP USGS | OP USGS |
| P&W 2 | A | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| Site 14 | A | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| USGS 19 | A | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| USGS 27 | A | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| USGS 65 | S | OP USGS | OP USGS | OP | OP USGS | OP USGS |
| USGS 85 | S | OP | OP USGS | OP | OP USGS | OP USGS |
| USGS 87 | S | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| USGS 100 | S | OP | OP USGS | OP USGS ^a | OP USGS | OP |
| USGS 104 | S | OP | OP USGS | OP | OP USGS | OP USGS |
| USGS 112 | S | OP | OP USGS | OP | OP USGS | OP USGS |
| USGS 115 | S | OP | OP USGS | OP | OP USGS | OP USGS |
| USGS 120 | S | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| Boundary Locations | | Organizations | | | | |
| Atomic City | Q/S/A | OP ESER ^c | OP USGS ESER | OP | OP USGS | OP USGS |
| Highway 3 | A | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| Mud Lake Water Supply | Q | OP ESER ^c | OP ESER ^c | OP | OP | OP |
| USGS 8 | A | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| USGS 11 | S | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| USGS 14 | S | OP USGS | OP USGS | OP USGS ^a | OP USGS ^b | OP USGS |
| USGS 103 | S | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| USGS 108 | S | OP USGS | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| USGS 124 | S | OP | OP USGS | OP | OP USGS | OP |
| USGS 125 | S | OP | OP USGS | OP USGS ^a | OP USGS | OP USGS |
| Distant Locations | | Organizations | | | | |
| Alpheus Spring | Q/S | OP ESER ^c | OP ESER | OP ^{**} | OP ^{**} | OP ^{**} |
| Bill Jones Hatchery | Q/S | OP ESER ^c | OP ESER | OP ^{**} | OP ^{**} | OP ^{**} |
| Clear Spring | Q/S | OP ESER ^c | OP ESER | OP ^{**} | OP ^{**} | OP ^{**} |
| Minidoka Water Supply | Q/S | OP ESER ^c | OP ESER | OP ^{**} | OP ^{**} | OP ^{**} |
| Shoshone Water Supply | Q/S | OP ESER ^c | OP ESER | OP ^{**} | OP ^{**} | OP ^{**} |

Table 2-4 continued. Interprogram water monitoring sampling schedules and analyses, 2002

| Co-located/Replicate Sample Analysis | | Radiological | | | Nonradiological | |
|--------------------------------------|------------|---|---------|--------|-----------------|-----------|
| Analysis | Frequency* | Gross Alpha, Gross Beta, Gamma Spectroscopy | Tritium | Metals | Common Ions | Nutrients |
| Magic Valley Sampling Program | | Organizations | | | | |
| MV 01 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 02 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 03 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 04 ^d | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 05 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 06 ^d | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 07 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 09 ^d | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 10 ^d | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 11 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 12 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 13 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 14 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 15 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 16 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 17 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 18 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 19 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 20 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 21 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 23 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 24 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 25 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 26 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 27 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 29 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 30 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 31 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 32 ^d | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 33 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 35 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 36 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 37 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 38 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 39 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |

Table 2-4 continued. Interprogram water monitoring sampling schedules and analyses, 2002

| Co-located/Replicate Sample Analysis | | Radiological | | Nonradiological | | |
|--|------------|----------------------|---------|-----------------|-------------|-----------|
| Analysis | Frequency* | Alpha, Beta, Gamma | Tritium | Metals | Common Ions | Nutrients |
| MV 40 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 41 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 42 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 43 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 45 ^d | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 46 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 47 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 48 (USGS 11) | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 49 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 50 ^d | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 51 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 52 ^d | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 53 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 54 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 55 ^d | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 56 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 57 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 58 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 59 | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| MV 61 (USGS 14) | T | OP USGS ^c | OP USGS | USGS | USGS | USGS |
| Surface Water Locations | | Organizations | | | | |
| Birch Creek at Blue Dome | S | OP | OP USGS | OP | OP USGS | OP USGS |
| Big Lost River at Experimental Field Station | S | OP USGS | OP USGS | OP USGS | OP USGS | OP USGS |
| Big Lost River at INEEL Diversion | S | OP USGS | OP USGS | OP USGS | OP USGS | OP USGS |
| <p>* Sampling Frequency Abbreviations: Q = Quarterly S = Semiannually T = Triennially Q/S = Quarterly by OP, semiannually by USGS</p> <p>** OP collects samples that are analyzed for metals, chloride, and nutrients at these distant sites annually.</p> <p>^a The USGS samples only for chromium at these locations; the OP samples for all the metals listed in the text.</p> <p>^b The USGS samples only for chloride at these location; the OP samples for all the common ions listed in the text.</p> <p>^c The specified co-sampling organization does not analyze samples from these sites by gamma spectroscopy.</p> <p>^d This site discontinued starting 2002, but available as alternate.</p> | | | | | | |

Table 2-5. Verification sampling program's water monitoring schedules and analyses, 2002

| Location/Analytes | Sampling Frequency ^a | Radiological ^b | Nonradiological | |
|---|---------------------------------|---------------------------|-------------------------|-------------------|
| | | | Inorganics ^c | VOCs ^d |
| Effluent | | | | |
| ANL-W Industrial Waste Ditch | A | X | X | |
| ANL-W Industrial Waste Pond | A | X | X | |
| Influent to CFA sewage treatment facility | A | | X | |
| Effluent from CFA sewage treatment facility | A | X | X | |
| Influent to INTEC sewage treatment facility | A | | X | |
| Effluent from INTEC sewage treatment facility | A | X | X | |
| INTEC Percolation Ponds | A | X | X | |
| NRF Industrial Waste Ditch | T | X | X | |
| NRF Sewage Lagoon | S | X | X | |
| TAN Disposal Pond | A | X | X | |
| TRA Cold Waste Pond | A | X | X | |
| Groundwater | | | | |
| ANL-MON-A-014 | A | X | X | |
| ARA-MON-A-002 | A | X | X | X |
| ARA-MON-A-003 | A | X | X | X |
| M1S | Q | X | X | X |
| M3S | Q | X | X | X |
| NRF-6 | A | X | X | X |
| NRF-9 | A | X | X | X |
| NRF-11 | A | X | X | X |
| NRF-12 | A | X | X | X |
| TAN-10A | A | | X | |
| TAN-13A | A | | X | |
| TAN-21 | A | X | X | X |
| TAN-37 | A | X | X | X |
| TAN-38 | A | X | X | X |
| TAN-40 | A | X | X | X |
| TAN-48 | A | X | X | X |
| TAN-51 | A | X | X | X |
| TRA-7 | A | X | X | |
| USGS-52 | A | X | X | |
| USGS-55 | A | X | X | |
| USGS-67 | A | X | X | |
| USGS-123 | A | X | X | |

^a Sampling Frequency Abbreviations: A=annually, q=quarterly, S=semiannually, T=tri-annually

^b Radiological analyses include one or more of the following: americium-241, gamma spectroscopy, gross alpha radioactivity, gross beta radioactivity, neptunium-237, plutonium isotopes, strontium-90, technetium-99, tritium, and uranium isotopes.

^c Inorganic analyses include various metals, common ions, and nutrients.

^d Volatile organic compounds

Chapter 3

Air Monitoring

Major Findings and Developments

Gross alpha and gross beta screening measurements of particulate air filters were consistent with historical background concentrations. Elevated concentrations were observed during periods associated with temperature inversions. Atmospheric tritium and tritium concentrations in precipitation collected at boundary and distant monitoring locations were consistent with the range of historical background concentrations and typically below detection levels. Atmospheric tritium concentrations observed at onsite monitoring locations were well below regulatory limits.

- No offsite environmental impacts from INEEL operations were evident based on the results of particulate air sampling using TSP samplers.
- Strontium-90 was measured at several monitoring locations. Concentrations were slightly greater than the laboratory's detection capability, yet were significantly below the INEEL OP action level.
- Radioactive iodine was **not** detected in air samples as observed in past years.
- No offsite environmental impacts from INEEL operations were detected in precipitation samples.
- Tritium was measured at several monitoring locations. Concentrations were slightly greater than the laboratory's detection capability, yet were significantly below the INEEL OP action level.
- Interprogram comparisons of different surveillance program results show poor to relatively good agreement. Discrepancies have been traced to differences in sampling methodologies, schedules, and laboratory detection capabilities.

Primary Air Results and Trends

Particulate and Iodine-131 Air Sampling

INEEL OP conducts continuous particulate air sampling at 11 locations. Ten stations are owned and maintained by the INEEL OP and one station is owned and maintained by the Shoshone-Bannock Tribes at the Fort Hall Environmental Monitoring Station (EMS). INEEL OP conducts particulate air sampling using high-volume, total suspended particulate (TSP) samplers. Air is pulled through a 10.2-mm (4-inch) diameter filter at approximately 170-L/min (6.0 SCFM¹) and the volume of air sampled is measured using a mass-flow meter.

To supplement the particulate air sampling, three intermediate-flow PM₁₀ samplers are operated (two at boundary locations Atomic City and Mud Lake/Terreton and one at the Fort Hall EMS). These samplers selectively sample suspended particulate matter with aerodynamic diameters² less than or equal to 10- μ m³ onto a 10.2-mm (4-inch) diameter filter at approximately 112-L/min (4.0 ACFM⁴) and the volume of air sampled is measured using a volumetric flow meter. These samplers are operated in areas where agricultural activities may pose mass loading⁵ problems for the TSP samplers.

INEEL OP collects particulate air samples weekly. During the 2002 calendar year, INEEL OP began using high-volume TSP samplers as the primary particulate air samplers after a two-year investigation comparing these samplers to the PM₁₀ samplers used for the past several years. Availability of replacement and maintenance parts for aging PM₁₀ samplers indicated a need for an alternative with “off-the-shelf” components for easy repair and replacement.

Particulate air filters are collected weekly and these filters are analyzed in a timely manner, using a gross screening analysis (gross alpha and gross beta). Gross screening analyses of air filters collected during 2002 indicated the presence of radioactive material at concentrations associated with radionuclides found naturally in the environment (**Table 3-1**).

¹ Standard Cubic Feet per Minute (SCFM) is a unit of volumetric flow rate of 1 cubic foot of air per minute at standard conditions (760mm Hg or 29.9inches of Hg and 20°C).

² Similar behavior to a unit density sphere (water droplet) with a diameter of 10 μ m.

³ A micron or micrometer corresponds to one-millionth of a meter.

⁴ Actual Cubic Feet per Minute (ACFM) corresponds to the actual volumetric flow rate at ambient conditions with the units cubic feet per minute.

⁵ Mass loading is the condition where particulate matter accumulates to such an extent that the filter can no longer collect and trap suspended particulate matter. Additionally, the particulate matter trapped on the filter may restrict flow to such an extent that the pump or blower does not provide adequate pressure difference to maintain desired flow rates.

Table 3-1. Descriptive statistics for 2002 particulate air sampling gross screening results from TSP samplers. Screening results given in femtocuries^a per cubic meter (fCi/m³).

| | Boundary Gross Alpha (fCi/m³) | Boundary Gross Beta (fCi/m³) | Distant Gross Alpha (fCi/m³) | Distant Gross Beta (fCi/m³) | Onsite Gross Alpha (fCi/m³) | Onsite Gross Beta (fCi/m³) |
|---|---|--|--|---|---|--|
| Average: | 0.9 | 26.0 | 1.0 | 22.5 | 1.0 | 28.8 |
| Median: | 0.8 | 22.1 | 1.0 | 19.9 | 0.9 | 25.6 |
| Standard Deviation: | 0.7 | 14.5 | 0.7 | 13.6 | 0.8 | 15.9 |
| Minimum: | 0.2 | 9.2 | 0.2 | 4.4 | 0.3 | 9.9 |
| Maximum: | 6.3 | 101.1 | 4.9 | 78.5 | 6.3 | 93.5 |
| # Exceeding Action Level: | 5 | 3 | 3 | 2 | 4 | 10 |
| Number of Measurements: | 547 | | | | | |
| 2-year investigation results comparing PM ₁₀ and TSP at each monitoring station ^b | PM ₁₀ Gross Alpha (fCi/m ³) | TSP Gross Alpha (fCi/m ³) | PM ₁₀ Gross Beta (fCi/m ³) | TSP Gross Beta (fCi/m ³) | | |
| Average: | 1.1 | 0.9 | 36.2 | 25.4 | | |
| Median: | 1.0 | 0.8 | 31.0 | 22.7 | | |
| Standard Deviation: | 0.5 | 0.6 | 21.3 | 13.0 | | |
| Minimum: | 0.0 | 0.1 | 5.1 | 4.4 | | |
| Maximum: | 3.2 | 6.3 | 142.0 | 101.1 | | |
| Number of co-samples: | 989 | | 989 | | | |
| Percent Agreement: | 95.7% | | 57.7% | | | |
| ^a Femtocurie corresponds to 10 ⁻¹⁵ Curie or 10 ⁻³ picocurie | | | | | | |
| ^b Investigation compared analytical results of filters collected at INEEL OP monitoring stations using intermediate-flow PM ₁₀ samplers and high-volume TSP samplers during 2001 and 2002 calendar years. | | | | | | |

To streamline the decision-making process, the INEEL OP has established action levels⁶ for gross alpha for gross alpha and gross beta screening analyses based solely upon dose considerations. Action levels for weekly screening measurements assume that all of the alpha activity on the filter is from americium-241, and that all of the beta activity on the filter is from strontium-90. Using the dose conversion factors from the Environmental Protection Agency's (EPA) Federal Guidance Report Number 11 (FGR11)⁷, assuming a constant air concentration, and assuming a breathing rate of 10,000 m³/y. Action levels were set at 50-μSv/y (5 mrem per year) for gross alpha and 10-μSv/y (1 mrem per year) for gross beta. This corresponds to a gross alpha action level of 2.1 femtocuries⁸ per cubic meter (fCi m⁻³). The gross alpha action level derived from a gross alpha concentration of 1.1 fCi/m³ corresponds to 50-μSv/y (5 mrem per year) from americium 241 plus the typical gross alpha background of 1.0 fCi/m³. The gross beta action level is 77 fCi/m³ corresponding to 10-μSv/y from strontium-90.

⁶ Action Levels correspond to a dose equivalent of 50 microSieverts (50 μSv or 5 mrem) per year for gross alpha and 10 microSieverts (10 μSv or 1 mrem) per year for gross beta. Action Levels were derived from ICRP 30 dose conversion factors assuming a breathing rate of 10,000 m³ per year.

⁷ US EPA, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11," EPA 520/1-88-020, September 1988.

⁸ 1 femtocurie = 10⁻¹⁵ curies or 10⁻³ picocuries.

Measurements that exceed the action level are compared to those measurements from distant locations. If the difference in concentrations between the distant sites and the boundary or onsite monitoring locations exceeds 1.1 fCi/m^3 for gross alpha or 77 fCi/m^3 for gross beta, an additional analysis of the filter (i.e., gamma spectroscopic analysis) is performed. Of the 547 TSP filters deployed during 2002, 98 percent of the gross alpha and 97 percent of the gross beta measurements were less than the action level. Of the individual weekly measurements exceeding the action level, no man-made radionuclides were identified via gamma spectroscopic analysis.

Generally, gross alpha and gross beta activity fluctuate seasonally (**Figure 3-1** and **Figure 3-2**). Each year, including 2002, gross beta activity tends to increase during winter months (**Figure 3-2**). Elevated measurements are attributed to temperature inversions that hold radon progeny in the lower portion of the atmosphere. The plots include data from two years to demonstrate seasonal fluctuations attributed to fluctuations in natural background.

INEEL OP monitors for radioactive iodine-131 by drawing air through a RADeCo BG-300 impregnated charcoal cartridge. The activated charcoal cartridge preferentially adsorbs gases (e.g., noble gases and iodine). The cartridges are deployed in the field for a week at a volumetric flow rate of approximately 112-L/min (4.0 ACFM) and the volume of air sampled is measured using a volumetric flow meter. Radioiodine samplers are analyzed in a batch process⁹ via gamma spectroscopy.

The action level for airborne radioactive iodine is 21 fCi/m^3 that corresponds to 10 percent of the Table 2, 40 CFR 61, Appendix E compliance value. Radioactive iodine has not exceeded the laboratory *a priori* MDC of 0.55 fCi/m^3 since INEEL OP began sampling for radioiodine in 1993.

No man-made, gamma-emitting radionuclides were identified on TSP quarterly composite filters deployed during 2001 or 2002. To obtain measurement results, the laboratory has the capability to “force” the software to report a measurement even though no peak is distinguishable from the background continuum. “Forced” measurements of quarterly cesium-137 concentrations for TSP filters are shown for onsite, boundary, and distant locations in **Figure 3-3** for 2001 and 2002.

⁹ All of the cartridges collected by INEEL OP are analyzed at the same time in a single batch within 24 hours of collection. In event that iodine-131 is observed during the “batch” analysis, individual cartridges will be analyzed to determine iodine-131 concentrations at each monitoring station. Under such circumstances, the individual cartridges will be analyzed within 72 hours of collection.

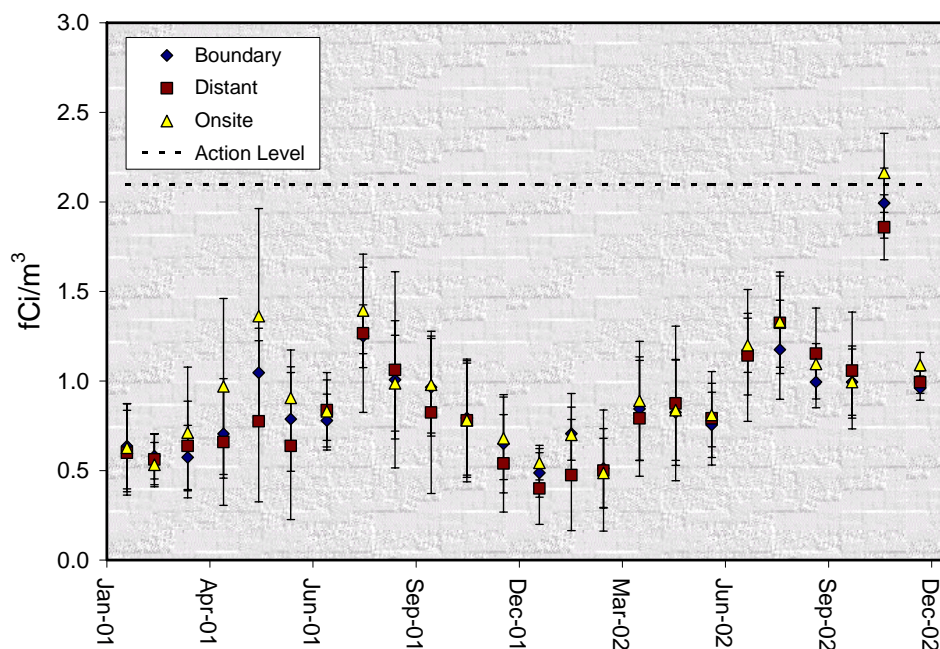


Figure 3-1. Average gross alpha screening results of TSP filters collected during 2001 and 2002. The dotted line corresponds to the gross alpha action level, 2.1 fCi/m³. This concentration corresponds to approximately 5 μ Sv (5 mrem) per year assuming all of the activity is due to inhalation of americium-241 and remains constant for an entire year.

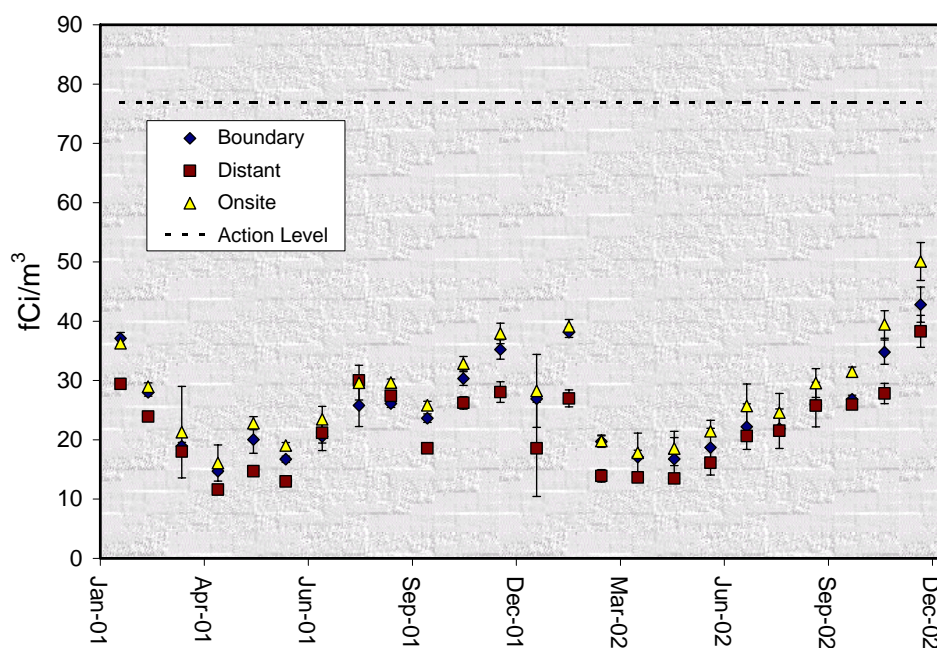


Figure 3-2. Average gross beta screening results of TSP filters collected during 2001 and 2002. The dotted line corresponds to the gross beta action level, 77 fCi/m³. This concentration corresponds to approximately 10 μ Sv (1 mrem) per year assuming all of the gross beta activity is due to inhalation of strontium-90 and remains constant for an entire year.

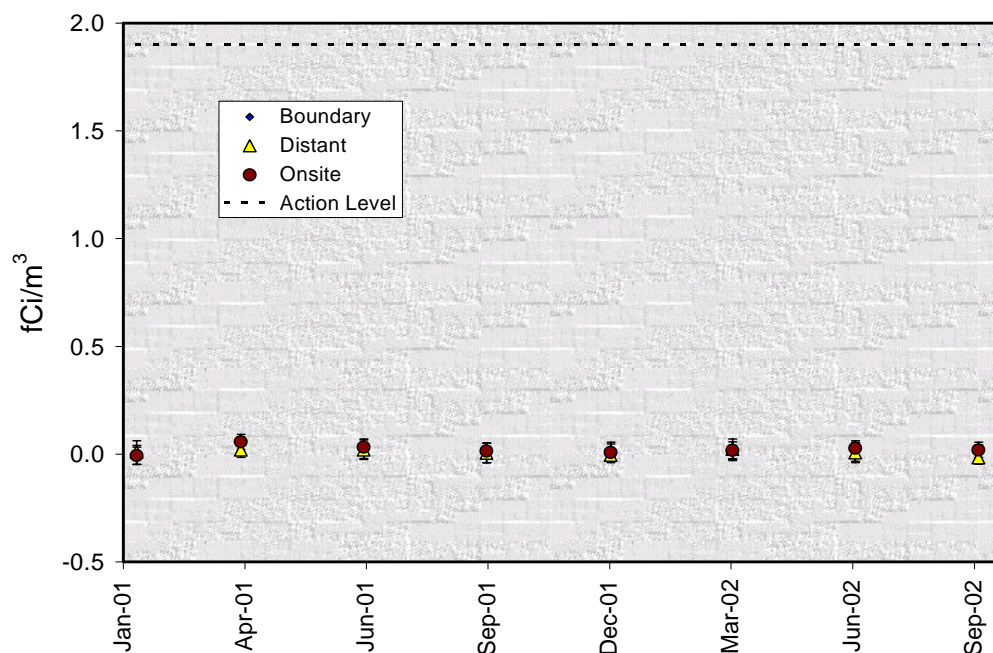


Figure 3-3. Gamma spectroscopic analytical results (i.e., cesium-137) for quarterly composite TSP filters collected during 2001 and 2002. The action level corresponds to 10 percent of the value listed for compliance (for cesium-137) in Table 2 of 40CFR61, Appendix E.

Some radionuclides released to the environment as a result of INEEL operations are not easily identified and quantified using standard gamma spectroscopic analytical techniques. Radionuclides including strontium-90, americium-241, plutonium-238, and plutonium 239/240 are analyzed using sophisticated, destructive radiochemical separation. Since radiochemical separation involves destruction of the filter media, annual composites are submitted for analysis only after all non-destructive analyses (i.e., gross alpha, gross beta, gamma spectroscopy) have been completed. No americium-241, plutonium-238, or plutonium 239/240 was observed on annual composites. (i.e., none exceeded both the laboratory *a priori* MDC and the 3-sigma counting uncertainty.).

Radiochemical separation measurements for strontium-90 exceeded both the laboratory *a priori* MDC and the 3-sigma counting uncertainty at 9 of the 11 monitoring stations (**Table 3-2** and **Table 3-3**). None of the strontium-90 concentrations exceeded the INEEL OP's action level. Historically, strontium-90 has been observed in annual composite samples that have been analyzed via radiochemical separation. Summary results of historical strontium-90 concentrations are shown for onsite, boundary and distant monitoring locations in **Figure 3-4**.

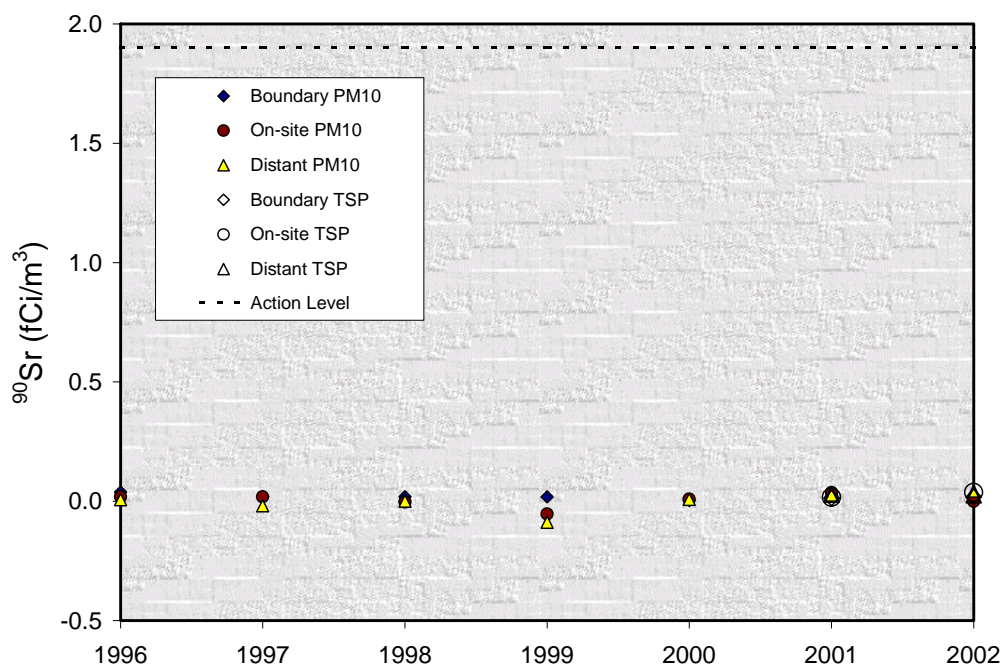


Figure 3-4. Summary of radiochemical separation analysis results of annual composites of particulate air filters collected by INEEL OP at onsite, boundary, and distant monitoring locations since 1996. The dotted line corresponds to the INEEL OP action level for strontium-90 that corresponds to 10 percent of the compliance value listed in Table 2 of 40CFR61, Appendix E.

The action levels for radiochemical separation results used by INEEL OP correspond to 10 percent of the compliance limit listed in Table 2 of 40CFR61, Appendix E¹⁰. The compliance limit listed in Table 2 of 40CFR61, Appendix E, provides an alternative to determining compliance with EPA National Emission Standards for Hazardous Air Pollutants (NESHAP) other than calculating the total effective dose equivalent (TEDE) to the maximally exposed member of the public using EPA-approved computer codes.

Atmospheric Moisture and Precipitation

INEEL OP monitors atmospheric tritium concentrations by collecting atmospheric moisture samples at 11 monitoring locations. Ambient tritium is assumed to be in the form of tritiated water vapor (i.e., HTO). As air passes through a desiccant material, the atmospheric moisture adsorbs to the desiccant. The atmospheric moisture is then driven off from the desiccant by heating the desiccant material and collecting the liquid distillate. The liquid distillate is then analyzed for tritium via liquid scintillation counting. Atmospheric tritium concentrations are then calculated using the tritium concentration in the distillate, the quantity of atmospheric moisture collected, and the volume of air sampled.

¹⁰ National Emission Standards for Hazardous Air Pollutants (NESHAPs), Appendix E – Compliance Procedures Methods for Determining Compliance with Subpart I – National Emission Standards for Radionuclide Emissions from Federal Facilities other than Nuclear Regulatory Commission Licensees and not covered by Subpart H, Table 2 - Concentrations Levels for Environmental Compliance.

Table 3-2. Analysis results for strontium-90 in annual composite samples of TSP filters deployed during 2002. All values in attocuries^a per cubic meter (10^{-6} pCi/m³)

| Location | ⁹⁰ Sr | 2-sigma | MDC | Percent of Action Level ^b |
|----------------------------|------------------|---------|------|--------------------------------------|
| Boundary Locations | | | | |
| Atomic City | 11.4 | 7.3 | 10.2 | 0.6% |
| Howe | 41.4 | 11.9 | 13.9 | 2.2% |
| Montevieu | 0.5 | 0.4 | 9.3 | ND ^c |
| Mud Lake/Terreton | 20.6 | 8.8 | 11.3 | 1.1% |
| Distant Locations | | | | |
| Craters of the Moon | 42.5 | 12.0 | 13.9 | 2.2% |
| Fort Hall | 11.5 | 8.5 | 12.3 | ND ^c |
| Idaho Falls | 22.2 | 7.8 | 8.5 | 1.2% |
| Blank Sample ^d | -3.1 | 4.1 | 9.5 | ND ^c |
| Onsite Locations | | | | |
| Big Lost River Rest Area | 34.0 | 9.8 | 9.6 | 1.8% |
| Experimental Field Station | 33.4 | 10.6 | 12.2 | 1.8% |
| Sand Dunes | 37.3 | 9.7 | 8.6 | 2.0% |
| Van Buren Avenue | 45.5 | 10.1 | 8.4 | 2.4% |

^a One attocurie corresponds to 10^{-18} curies or 10^{-6} picocuries.
^b Action Level corresponds to 10 percent of the value listed in Table 2 of 40CFR61, Appendix E.
^c Not detected
^d Blank filter. That is, no air was pulled through the blank sample. Air concentrations calculated by measuring activity on sample media and dividing by the average annual sample volume from each TSP sampler deployed during 2002.

Table 3-3. Descriptive statistics of strontium-90 results in annual composite samples of TSP filters deployed during 2002. All values in attocuries^a per cubic meter (10^{-6} pCi/m³)

| | Average | Median | Standard Deviation |
|-----------|---------|--------|--------------------|
| Boundary: | 18.4 | 16.0 | 17.4 |
| Distant: | 25.4 | 22.2 | 15.8 |
| Onsite: | 37.5 | 35.6 | 5.6 |

Action levels for airborne tritium are set at 10 percent of the compliance limit listed in Table 2 of 40CFR61, Appendix E. During 2002, the MDC for airborne tritium ranged between 0.1 and 1.1 pCi/m³. Atmospheric tritium was detected at onsite locations, Big Lost River Rest Area, Van Buren Avenue, and the Experimental Field Station, consistent with historical measurements. Atmospheric tritium has been consistently observed at these locations since the Three Mile Island (TMI-2) fuel fragments were placed in dry storage at the Idaho Nuclear Technology and Engineering Complex (INTEC). The observed concentrations of tritium at the onsite locations are significantly below the INEEL OP action level for airborne tritium (150 pCi/m³).

Tritium concentrations attributable to INEEL operations have not been observed at offsite monitoring locations (see **Figure 3-5**). INEEL OP has observed elevated tritium measurements

during periods that the analytical laboratory experienced tritium contamination problems in 1996, 1997, and 1998. Average quarterly atmospheric tritium concentrations with detection capabilities (corrected for laboratory MDC, quantity of atmospheric moisture collected, and volume of air sampled) are given in **Table 3-4** for atmospheric tritium monitoring efforts during 2002.

In 2001, INEEL OP began to consistently observe tritium at onsite air-monitoring stations (a trend that continued during 2002). The observed airborne tritium concentrations at the onsite locations were initially attributed to tritium contamination at the analytical laboratory. In 2001, the supporting technical information (i.e., Engineering Design Files) for the INEEL NESHAPs report indicated a 76.8-Ci/y release rate at the TMI-2 dry storage area. Using the same meteorology files used by INEEL for EPA NESHAPs dose calculations, INEEL OP calculated average annual tritium concentrations at EFS and Van Buren to be 9.8-pCi/m³ and 0.73-pCi/m³, respectively. Environmental measurements at EFS averaged 0.7-pCi/m³ (ranging from <MDC to 1.7-pCi/m³). Environmental measurements at Van Buren Avenue averaged 0.3-pCi/m³ (ranging from <MDC to 0.7-pCi/m³). This indicates either a slight overestimation on the part of the tritium release rate used by INEEL or an overestimation in atmospheric concentrations by EPA-approved computer code with respect to INEEL OP environmental monitoring results.

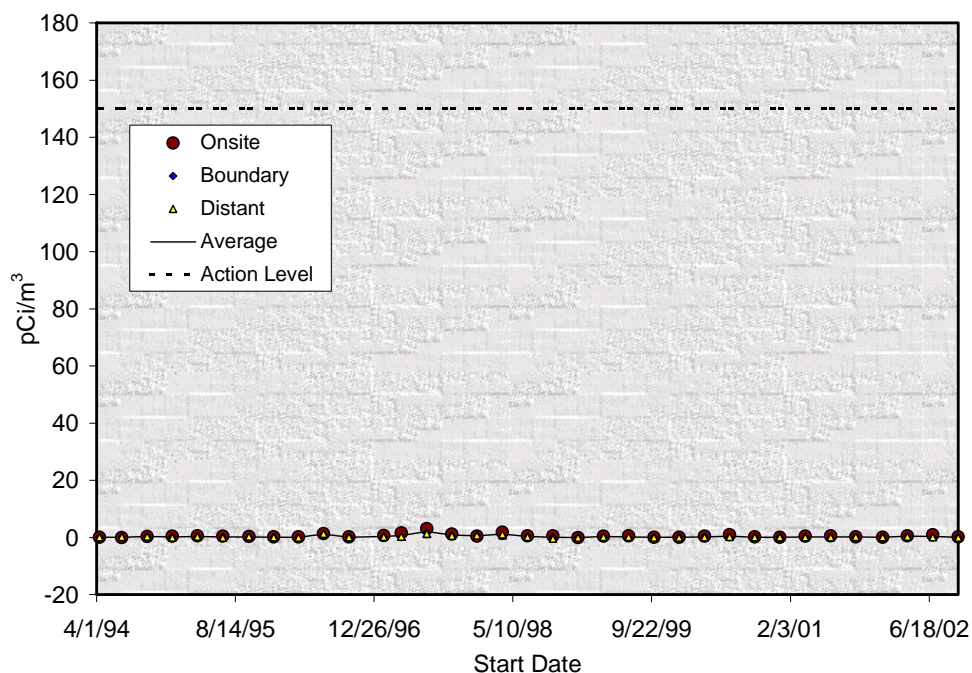


Figure 3-5. Average quarterly tritium concentrations observed at monitoring stations on the INEEL, near the site boundary, and at distant locations since 1994. The dotted line represents the INEEL OP action level or 10 percent of the compliance value listed in Table 2, 40CFR61, Appendix E.

Table 3-4. Average quarterly airborne tritium concentrations. All values given in picocuries per cubic meter (pCi/m³).

| Location | 1st Quarter 2002 | 1st Quarter 2002 MDC | 2 nd Quarter 2002 | 2 nd Quarter 2002 MDC | 3 rd Quarter 2002 | 3 rd Quarter 2002 MDC | 4 th Quarter 2002 | 4 th Quarter 2002 MDC |
|----------------------------|---------------------|----------------------------|---------------------------------|--|---------------------------------|--|---------------------------------|--|
| Atomic City | 0.04 ± 0.13 | 0.27 | 0.18 ± 0.27 | 0.43 | 0.08 ± 0.28 | 0.47 | -0.04 ± 0.16 | 0.28 |
| Howe | 0.00 ± 0.14 | 0.31 | 0.60 ± 0.44 | 0.71 | 0.13 ± 0.54 | 0.90 | 0.00 ± 0.28 | 0.48 |
| Mud Lake/Terreton | 0.06 ± 0.14 | 0.31 | 0.63 ± 0.42 | 0.65 | -0.09 ± 0.49 | 0.83 | 0.10 ± 0.28 | 0.49 |
| Montevue | 0.05 ± 0.09 | 0.22 | 0.32 ± 0.37 | 0.61 | 0.07 ± 0.62 | 1.04 | 0.04 ± 0.16 | 0.28 |
| Boundary Average: | 0.04 ± 0.03 | 0.28 | 0.43 ± 0.22 | 0.60 | 0.05 ± 0.10 | 0.81 | 0.02 ± 0.06 | 0.38 |
| Craters of the Moon | -0.01 ± 0.13 | 0.25 | 0.48 ± 0.42 | 0.67 | 0.25 ± 0.41 | 0.67 | 0.05 ± 0.22 | 0.39 |
| Fort Hall | 0.04 ± 0.07 | 0.11 | 0.09 ± 0.06 | 0.09 | -0.18 ± 0.59 | 1.00 | -0.19 ± 0.27 | 0.49 |
| Idaho Falls | 0.09 ± 0.17 | 0.37 | 0.41 ± 0.42 | 0.67 | 0.06 ± 0.37 | 0.61 | -0.05 ± 0.28 | 0.49 |
| Distant Average: | 0.04 ± 0.05 | 0.25 | 0.33 ± 0.20 | 0.48 | 0.04 ± 0.22 | 0.76 | -0.06 ± 0.12 | 0.45 |
| Experimental Field Station | 0.11 ± 0.14 | 0.29 | 0.95 ± 0.30 | 0.44 | 1.23 ± 0.47 | 0.72 | 0.35 ± 0.27 | 0.43 |
| Big Lost River Rest Area | 0.01 ± 0.13 | 0.30 | 0.23 ± 0.23 | 0.38 | 0.74 ± 0.44 | 0.70 | 0.18 ± 0.23 | 0.38 |
| Sand Dunes | 0.10 ± 0.13 | 0.29 | 0.46 ± 0.33 | 0.55 | 0.25 ± 0.41 | 0.67 | -0.02 ± 0.26 | 0.45 |
| Van Buren Avenue | 0.09 ± 0.14 | 0.30 | 0.70 ± 0.36 | 0.55 | 1.44 ± 0.45 | 0.66 | 0.28 ± 0.25 | 0.42 |
| Onsite Average: | 0.08 ± 0.04 | 0.30 | 0.59 ± 0.31 | 0.48 | 0.91 ± 0.53 | 0.69 | 0.20 ± 0.16 | 0.42 |

Precipitation is collected at six monitoring stations (Atomic City, Big Lost River Rest Area, Howe, Idaho Falls, Mud Lake/Terreton, and Montevideo). Precipitation (including rain and snow) is collected using a 1-square meter collection tray that is heated during winter months to facilitate the melting of snow. Precipitation is accumulated in a 19-L (5-gallon) carboy that is housed in an insulated housing to minimize evaporation. The samples are collected at the end of the calendar quarter or when the carboy is filled, whichever comes first.

Precipitation is analyzed for radionuclides that may have undergone atmospheric wash out. These water samples are analyzed for tritium via liquid scintillation counting and analyzed for gamma-emitting radionuclides via gamma spectroscopy.

The laboratory reports a MDC of 160 pCi/L for tritium and 6 pCi/L for cesium-137 and other gamma-emitting radionuclides. No man-made radionuclides have been observed in precipitation samples collected by INEEL OP.

Interprogram Comparisons of Air Sampling Results

Air quality measurements made by the INEEL OP agreed moderately well with measurements made by DOE-ID contractors during 2002. Differences were expected due to differences in monitoring schedules and significant differences in air sampling methods used by each organization.

Comparisons were made for air monitoring efforts conducted for DOE-ID by S. M. Stoller through the Environmental Surveillance, Education and Research Program (ESER) and Bechtel BWXT Idaho, LLC (BBWI).

Air Monitoring – Suspended Particulate Matter

Gross screening results from particulate air samples collected by INEEL OP, ESER, and BBWI from Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue monitoring stations were compared. Gross alpha and gross beta screening measurements are performed on filters collected each week after the filters have been weighed (to determine mass concentrations of suspended particulate matter) and the filters have been stored long enough to allow for the decay of the short-lived radioactive progeny of radon. Most of the gross screening result is attributable to radioactive progeny of radon-220 and radon-222. Storage for three to five days removes over 99 percent of the contribution to gross alpha and gross beta measurements from short-lived decay products of radon.

The first comparisons made are with respect to the INEEL OP action levels for gross alpha and gross beta measurements. Average weekly gross screening results were plotted to identify potential temporal variations (**Figure 3-6** for gross alpha results and **Figure 3-7** for gross beta results). Temporal variations are expected due to temperature inversions experienced during the winter months that trap radon gas in the lower atmosphere. Gross alpha and gross beta screening analyses performed by INEEL OP and DOE-ID contractors exceeded INEEL OP action levels

during periods of temperature inversions. The elevated measurements were attributable to natural fluctuations in background since no man-made radionuclides were identified via gamma spectroscopic analysis during the periods in question. No gamma-emitting radionuclides were identified by INEEL OP or by DOE-ID contractors during 2002.

Secondly, measurements made during corresponding weeks are compared. Variations are expected for direct comparisons due to differences in sampling schedules, differences in sampling techniques, and differences in laboratory analysis.

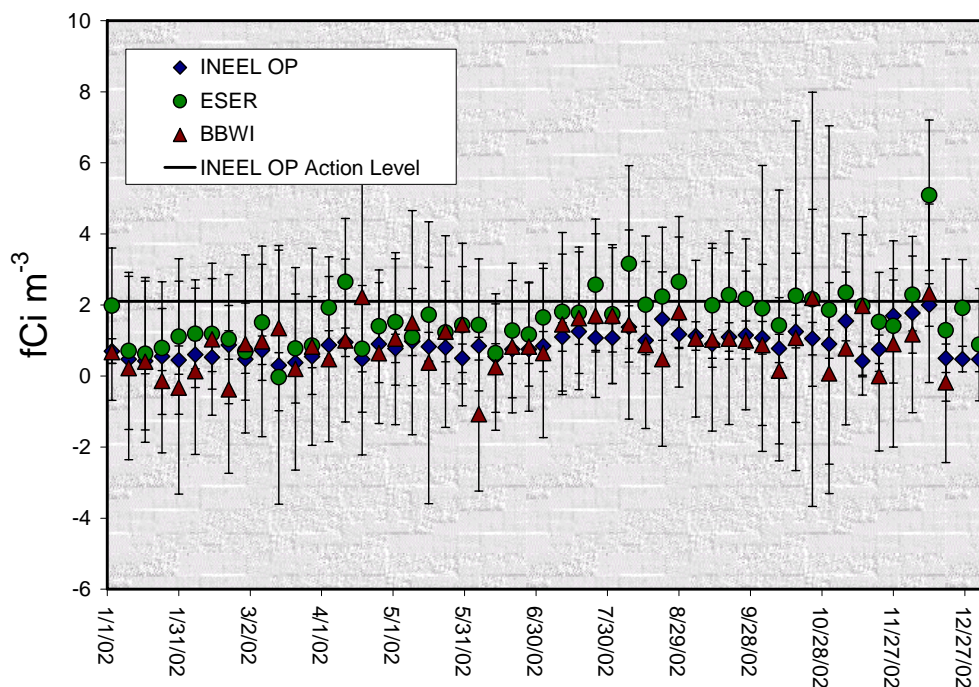


Figure 3-6. Average weekly gross alpha screening results for samples collected at Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue. The INEEL OP action level corresponds to an airborne concentration corresponding to an inhalation dose of 50 μ Sv/y (5 mrem per year). This assumes all of the alpha emissions are due to americium-241, an annual breathing rate of 10,000 m³/y, and an average gross alpha background of 1.0 fCi/m³, and the air concentration remains constant over the entire year.

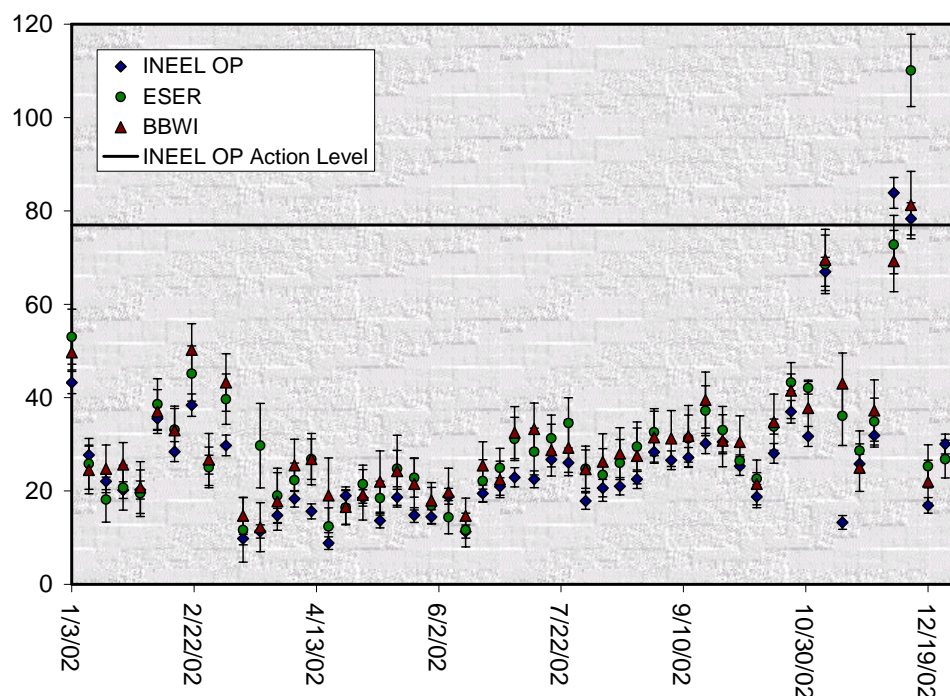


Figure 3-7. Average weekly gross beta screening results for samples collected at Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue. The INEEL OP action level corresponds to an airborne concentration corresponding to an inhalation dose of $10 \mu\text{Sv/y}$ (1 mrem per year). This assumes all of the beta emissions are due to strontium-90, an annual breathing rate of $10,000 \text{ m}^3/\text{y}$, and the air concentration remains constant over the entire year.

Gross alpha screening results are typically very small, have relatively large measurement uncertainty, and a relatively small range of measurement values are observed during natural fluctuations. These factors make linear regression analysis of gross alpha screening results meaningless, therefore each INEEL OP measurement is compared to a DOE-ID measurement during a similar monitoring period and the two measurements are considered “in agreement” if the following expression holds true.

$$\{3 * (\sigma_{C1}^2 + \sigma_{C2}^2)^{1/2}\} \geq |C_1 - C_2|$$

Where,

C_1 = first measurement,

C_2 = second measurement,

σ_{C1} = 1-sigma uncertainty of first measurement, and

σ_{C2} = 1-sigma uncertainty of second measurement.

Gross beta screening results are considered to be “in agreement” if either the above expression holds true or if the absolute value of the relative percent difference of the two measurements (with respect to the mean of the two measurements) is less than 20 percent. The descriptive

statistics and results of direct comparisons of gross alpha and gross beta screening analyses are shown in **Table 3-5**.

Since gross beta concentrations vary over an order of magnitude during the course of a year, linear regression analysis was used to compare gross beta measurements made by INEEL OP and DOE-ID contractors. A plot comparing gross beta results obtained by INEEL OP and DOE-ID contractors at Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue is shown in **Figure 3-8**. The linear expression for each progression is shown along with the corresponding correlation coefficient.

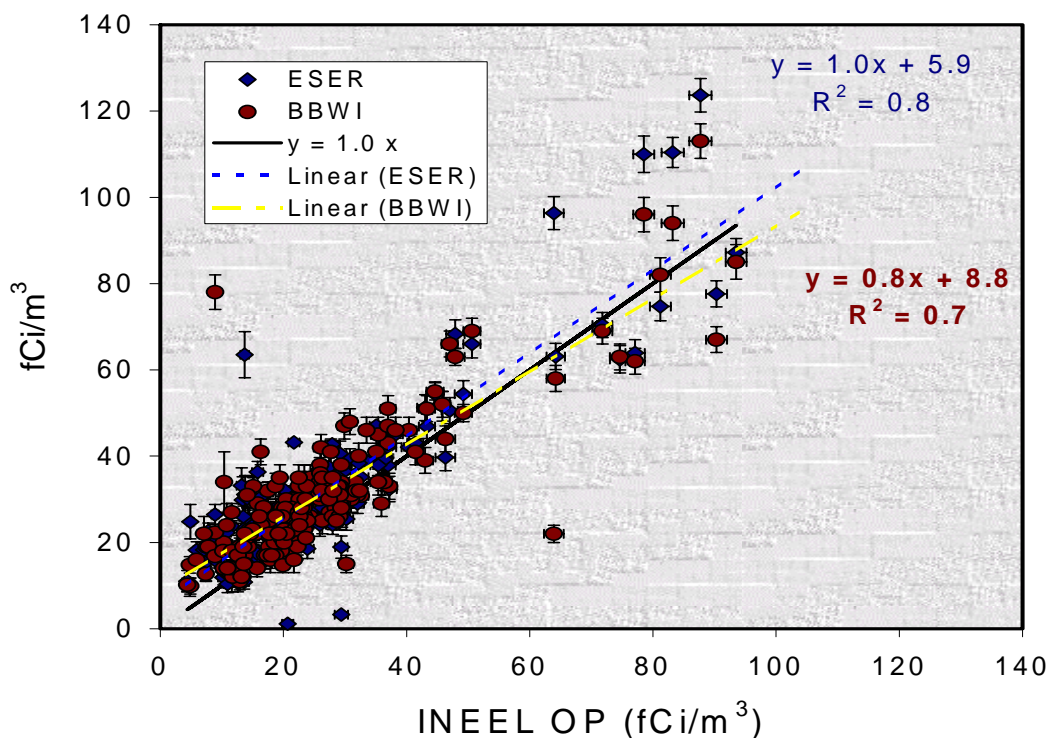


Figure 3-8. Plot comparing gross beta screening results from particulate air filters collected by INEEL OP and DOE-ID contractors at Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue during 2002. The corresponding equation is shown with each trend line with the corresponding correlation coefficient (R^2 -value). The trend line comparing INEEL OP and ESER data has a slope of 1.0 and the trend line comparing INEEL OP and BBWI data has a slope of 0.8. Both show relatively good agreement.

Table 3-5. Descriptive statistics of comparing INEEL OP gross alpha and gross beta screening results with DOE-ID results from co-located^a monitoring locations during 2002. Gross alpha and gross beta screening concentrations given in fCi/m³ (or 10⁻³ pCi/m³).

| | OP Gross Alpha | ESER Gross Alpha | OP Gross Beta | ESER Gross Beta |
|------------------------------|------------------|------------------|-----------------|-----------------|
| Average Value: | 0.9 | 1.7 | 25.8 | 30.8 |
| Median Value: | 0.8 | 1.5 | 22.5 | 27.3 |
| Standard Deviation: | 0.7 | 0.9 | 15.8 | 17.2 |
| Minimum Value: | 0.2 | -0.4 | 4.4 | 1.2 |
| Maximum Value: | 6.0 | 5.5 | 93.5 | 123.7 |
| Number of Pair Samples: | 204 | | 205 | |
| Percent in agreement: | 97.5% | | 99.0% | |
| Average Relative Difference: | NA ^b | | -9.8% | |
| | OP Gross Alpha | BBWI Gross Alpha | OP Gross Beta | BBWI Gross Beta |
| Average Value: | 1.0 | 0.9 | 25.8 | 30.7 |
| Median Value: | 0.9 | 0.7 | 22.3 | 27.0 |
| Standard Deviation: | 0.7 | 1.2 | 15.9 | 15.9 |
| Minimum Value: | 0.2 | -1.8 | 4.4 | 9.9 |
| Maximum Value: | 6.0 | 7.0 | 93.5 | 113.0 |
| Number of Pair Samples: | 198 | | 198 | |
| Percent in agreement: | 87.4% | | 79.8% | |
| Average Relative Difference: | NA ^b | | 10.4% | |
| | BBWI Gross Alpha | ESER Gross Alpha | BBWI Gross Beta | ESER Gross Beta |
| Average Value: | 0.9 | 1.7 | 30.6 | 30.9 |
| Median Value: | 0.7 | 1.5 | 27.0 | 27.3 |
| Standard Deviation: | 1.2 | 0.9 | 16.0 | 17.6 |
| Minimum Value: | -1.8 | -0.4 | 9.9 | 1.2 |
| Maximum Value: | 7.0 | 5.5 | 113.0 | 123.7 |
| Number of Pair Samples: | 195 | | 195 | |
| Percent in agreement: | 90.3% | | 92.3% | |
| Average Relative Difference: | NA ^b | | 0.4% | |

^a Co-located monitoring was conducted at the distant locations, Craters of the Moon National Monument and Idaho Falls, and the onsite locations, Experimental Field Station and Van Buren Avenue.

^b Not applicable due to the relatively small value with relatively large measurement uncertainty.

Air Monitoring – Gaseous Radionuclides

Radioactive Iodine

Each organization uses the RADeCo BN 300 impregnated charcoal cartridge in series with a particulate filter to collect radioiodine. Filters are analyzed within 24-hours of collection via gamma spectroscopy with close examination of the 364-keV Region of Interest associated with iodine-131.

Atmospheric Moisture - Tritium

ESER and INEEL OP showed relatively poor agreement for tritium concentrations in atmospheric samples collected at the Idaho Falls monitoring station during 2001 and 2002. The causes for this poor agreement are unknown, but speculation indicates problems associated with the type of desiccant material used by ESER for moisture collection or potential tritium contamination in the laboratory.

BBWI and INEEL OP showed very good agreement for atmospheric tritium monitoring results during 2001 and 2002. Elevated concentrations of atmospheric tritium were observed by both organizations at the EFS and Van Buren Avenue monitoring stations during 2nd and 3rd quarters of both years (**Figure 3-9**).

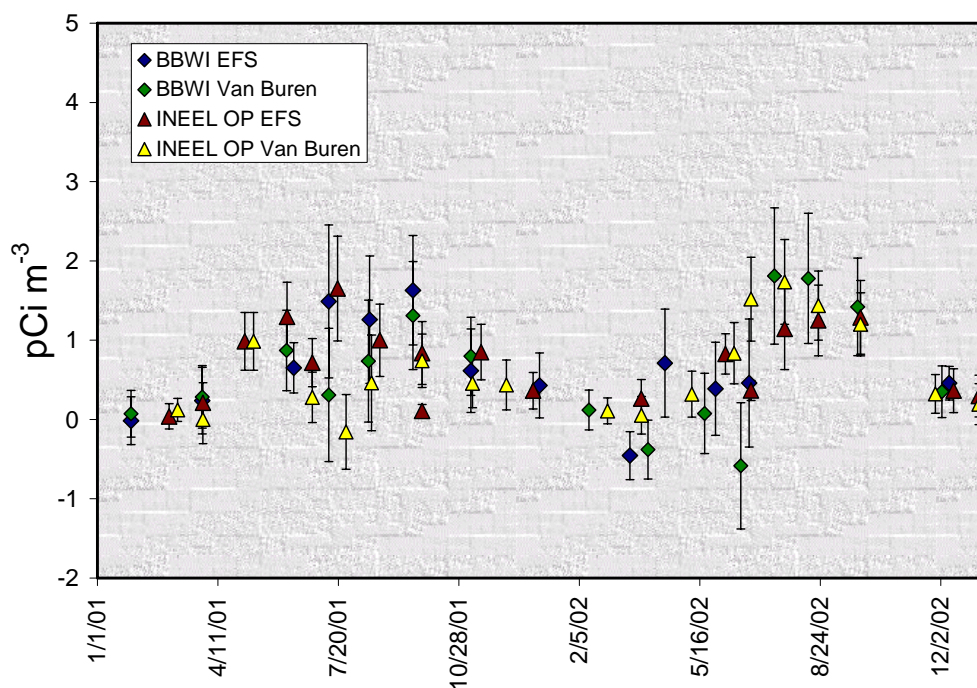


Figure 3-9. Airborne tritium concentrations at the Experimental Field Station and Van Buren Avenue monitoring stations during 2001 and 2002 calendar years. Elevated tritium concentrations were observed during the late spring and summer months likely due to releases attributable to the dry storage of the TMI-2 fuel fragments at INTEC. Elevated tritium concentrations were well below the INEEL OP action level of 150 pCi/m³.

Descriptive statistics of co-located atmospheric tritium monitoring results are shown in **Table 3-6**. Tritium concentrations in atmospheric moisture (distillate) samples collected by ESER and INEEL OP were obtained during 2001 and 2002 at the Idaho Falls station. Since the Idaho Falls station is considered a “distant” or “background” monitoring location, the elevated tritium concentrations in the atmospheric moisture samples were likely due to low levels of tritium contamination in the respective laboratories, a problem that has plagued both organizations for

the past two years. Descriptive statistics of airborne tritium concentrations observed by INEEL OP and BBWI at the Craters of the Moon, Experimental Field Station, Idaho Falls, and Van Buren Avenue monitoring stations are also shown in **Table 3-6**. The airborne concentrations observed by BBWI show good agreement with airborne concentrations observed by INEEL OP during 2001 and 2002.

Table 3-6. Descriptive statistics of atmospheric tritium monitoring efforts at co-located monitoring stations during 2001 and 2002

| | INEEL OP Moisture Concentration (pCi/L) ^a | ESER Moisture Concentration (pCi/L) ^a | INEEL OP Air Concentration (pCi/m ³) ^b | BBWI Air Concentration (pCi/m ³) ^b |
|--|---|---|--|---|
| Average: | 14.8 | 62.8 | 0.4 | 0.3 |
| Median: | 0.0 | 19.4 | 0.3 | 0.1 |
| Standard Deviation: | 50.4 | 72.7 | 0.5 | 0.6 |
| Minimum: | -40.0 | -0.2 | -0.30 | -0.98 |
| Maximum: | 200.0 | 193.6 | 1.74 | 1.81 |
| Number of Samples: | 22 | 20 | 80 | 58 |
| ^a Tritium concentration in atmospheric moisture samples collected at the Idaho Falls monitoring station. | | | | |
| ^b Airborne tritium concentrations determined from data collected at the Idaho Falls, Craters of the Moon, Experimental Field Station, and Van Buren Avenue Monitoring Stations. | | | | |

Even though there is significant disagreement in tritium values observed at the Idaho Falls monitoring station between INEEL OP and ESER results, the measurements made by each organization correspond to airborne concentrations that are significantly less than the INEEL OP action level of 150 pCi/m³ consistent with tritium concentration in moisture ranging from 30 to 90 nCi/L depending upon the absolute humidity during the sampling period.

Precipitation Sampling

Tritium concentrations observed in precipitation samples collected by INEEL OP and ESER at the Idaho Falls station were less than the INEEL OP detection capability (160 pCi/L). Slight discrepancies exist between the reported tritium concentrations in precipitation samples collected by INEEL OP and ESER (**Table 3-7**) due to reporting conventions used by each organization.

Table 3-7. Tritium concentrations observed in precipitation samples collected by INEEL OP and ESER at the Idaho Falls station during 2001 and 2002. Tritium concentrations in pCi/L

| | INEEL OP | ESER |
|--|----------------|----------------|
| Average Value: | -3 | 44 |
| Median Value: | -5 | 56 |
| Standard Deviation: | 42 | 79 |
| Minimum Value: | -70 | -196 |
| Maximum Value: | 70 | 125 |
| Number of Samples: | 8 | 15 |
| Number of Samples with Detectable Tritium: | 0 ^a | 7 ^b |
| ^a INEEL OP reports a minimum detectable concentration of 160 pCi/L. All of the precipitation samples collected by INEEL OP during 2002 had tritium concentrations less than MDC. | | |
| ^b ESER reports a tritium detection when the concentration exceeds the 2-sigma measurement uncertainty. These detectable concentrations ranged from 72 ± 58 to 125 ± 59 pCi/L, all less than the INEEL OP MDC. | | |

References:

National Council on Radiation Protection and Measurements, Exposure of the Population in the United States and Canada from Natural Background Radiation, NCRP Report Number 94, 1987.

National Council on Radiation Protection and Measurements, Measurement of Radon and Radon Daughters in Air, NCRP Report Number 97, 1988.

US EPA, EPA 402-B-92-001, Clean Air Act Assessment Package – 1988 (CAP88PC) computer code, Version 1.0, March 1992.

US EPA, “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11”, EPA 520/1-88-020, September 1988.

National Emission Standards for Hazardous Air Pollutants (NESHAPs), Appendix E – Compliance Procedures Methods for Determining Compliance with Subpart I – National Emission Standards for Radionuclide Emissions from Federal Facilities other than Nuclear Regulatory Commission Licensees and not covered by Subpart H, Table 2 – Concentration Levels for Environmental Compliance.

Chapter 4

Terrestrial Monitoring

Major Findings and Developments

Gamma spectroscopic analysis of soil samples and milk samples collected during 2002 were consistent with historical concentrations. INEEL OP observed no man-made radionuclides in milk samples collected during 2002, specifically iodine-131. Cesium-137 concentrations observed in soil were consistent with historical measurements on-site and within expected background concentrations, attributable to historical atmospheric nuclear weapons testing offsite.

- No offsite environmental impacts resulting from INEEL operations were indicated based on results from the analyses of milk or soil samples.
- No offsite environmental impacts resulting from INEEL operations were indicated based on results from *in-situ* soil analysis.

Primary Terrestrial Results and Trends

Terrestrial samples collected during 2002 indicated no concentrations of radionuclides attributable to INEEL operations above levels considered to pose a health risk. Terrestrial monitoring involves collecting milk samples from distribution centers, soil sampling, and *in-situ* gamma spectroscopic analysis at various soil monitoring locations. Milk and soil samples are analyzed specifically to identify gamma-emitting, manmade radionuclides.

Milk Sampling

Long-term radiological conditions are monitored by the INEEL OP through the collection of milk samples in southeastern Idaho. Raw, unprocessed milk samples are collected from dairy product distributors and analyzed for gamma-emitting radionuclides (e.g., cesium-137, iodine-131, potassium-40, etc.). Monitoring concentrations of gamma-emitting radionuclides in

foodstuffs provides an opportunity to verify any impact to the environment as a result of INEEL facility operations.

The philosophy for sampling the food pathway assumes that an atmospheric release will eventually reach a member of the public through the food supply. Such releases include radioactive forms of iodine or radioiodines. Radioiodines are produced in relative abundance during fission reactions. The chemical nature of iodine makes it relatively mobile under ambient conditions and, therefore, is likely to be released to the atmosphere during normal reactor operation and to be released in relatively large quantities during upset or emergency conditions.

The gaseous iodine will be transported through the environment via atmospheric dispersion until the iodine is deposited onto the ground (and other surfaces) and absorbed by plants or animals. Iodine is considered a nutrient necessary for proper metabolic function and indistinguishable from radioactive forms of iodine. Therefore, dairy cows (or goats) will tend to accumulate iodine from contaminated pasture or feed in milk via biological mechanisms through absorption or ingestion. When people ingest milk, the iodine will then accumulate in the thyroid gland. If the iodine is radioactive, this will result in an increased dose to the thyroid gland.

The biological mechanisms that accumulate iodine in milk provide a means to make an extremely sensitive measurement of radioactive material that may enter the food supply as a result of INEEL operations (e.g., reactor facility operation). INEEL OP specifically evaluates milk for isotopes of iodine that are easily observed, in relative abundance, and with radioactive half-lives long enough to potentially reach the public considering a four-day distribution time between milking and consumption. Short-lived isotopes such as iodine-123, iodine-130, iodine-132, iodine-133, iodine-134, and iodine-135 have radioactive half-lives that range from 53 minutes to 21 hours will likely decay to levels that are difficult to detect in the environment. Longer-lived isotopes such as iodine-125 and iodine 129 with low-energy beta radiation and relatively low abundance and low energy gamma photons make gamma spectroscopic analysis inappropriate for quantitative analysis. The remaining isotope is iodine-131 with a half-life of eight days, an abundant characteristic gamma photon.

INEEL OP collects milk samples as its sole ingestion-pathway monitoring program. The use of soil sampling and *in-situ* gamma spectrometry has provided insight as to the concentrations of radionuclides in soil. The known quantities of radionuclides in soil near the INEEL boundary in the agricultural regions with respect to plant uptake factors for radionuclides, has not indicated a need for additional food-pathway monitoring.

Milk samples are collected every month from four distribution centers representing five geographical areas in southeastern Idaho (**Figure 4-1**). Raw milk samples are transported in coolers to minimize separation and spoiling to the Idaho State University Environmental Monitoring Laboratory (ISU EML) as soon as physically possible and the milk samples are counted via gamma spectroscopy for iodine-131.

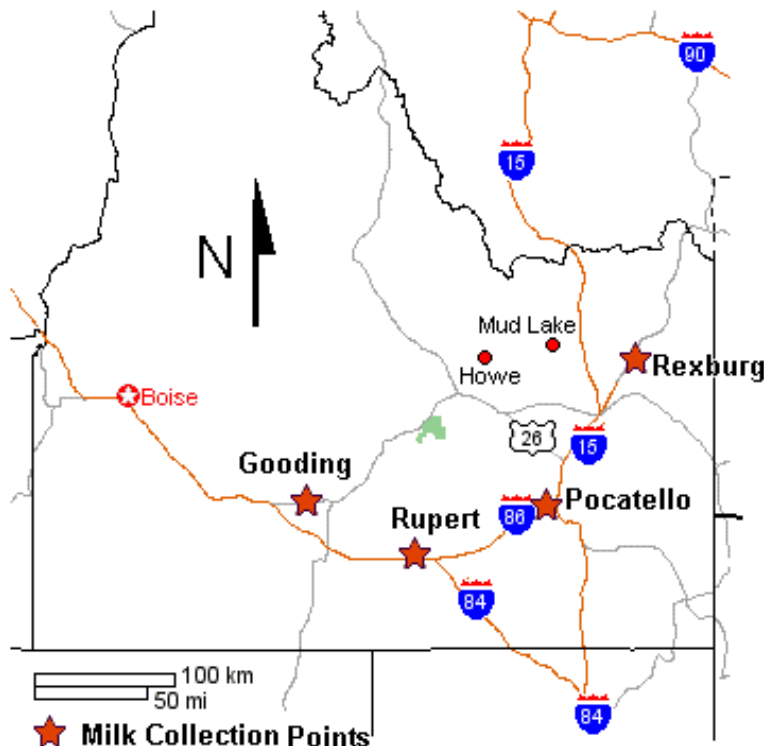


Figure 4-1. Routine milk collection points used by INEEL OP. Raw milk samples are collected at processing facilities at Gooding (Glanbia), Rupert (Kraft Foods), Pocatello (Meadowgold), and Rexburg (Nelson-Ricks). Two samples are collected at Nelson-Ricks from dairies near Howe and Mud Lake

INEEL OP requests that ISU EML report not only iodine-131 concentrations, but also potassium-40 that is found naturally in abundance of 0.012 percent of elemental potassium. The major radioactive constituent in many food products is potassium-40. The potassium-40 measurements performed by ISU EML provide a level of quality control in the measurement and indicate sensitivity. Historically, INEEL OP potassium-40 concentrations in milk have ranged between 1 and 2 nCi/L (approximately 1.5 nCi/L). Analytical results for iodine-131 and potassium-40 in milk are shown in **Figure 4-2** and summary descriptive statistics are given in **Table 4-1**.

Action levels for iodine-131 in milk correspond to 50 $\mu\text{Sv/y}$ (5 mrem per year) committed effective dose equivalent (CEDE) to the thyroid gland. Action levels were “back calculated” from dose to concentration using consumption rates and dose conversion factors listed in US NRC Regulatory Guide 1.109¹ for infants, children, teens, and adults. Additional assumptions included a four-day distribution time² and constant concentration for an entire year. The most

¹ US Nuclear Regulatory Commission, Regulatory Guide 1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I, Revision 1, October 1977.

² Table D-1, US NRC Regulatory Guide 1.109

restrictive assumptions correspond to a concentration of iodine-131 in milk of 4.4 pCi/L correlating to an infant thyroid CEDE of 50 μ Sv/y (5 mrem per year).

Concentrations of radioactive iodine in milk were not detected during 2002 (as shown in **Figure 4-2**). Since INEEL OP began collecting milk samples in 1996, iodine-131 has not been observed in concentrations greater than the ISU EML *a priori* MDC of 4 pCi/L and therefore has not exceeded the INEEL OP action level of 4.4 pCi/L.

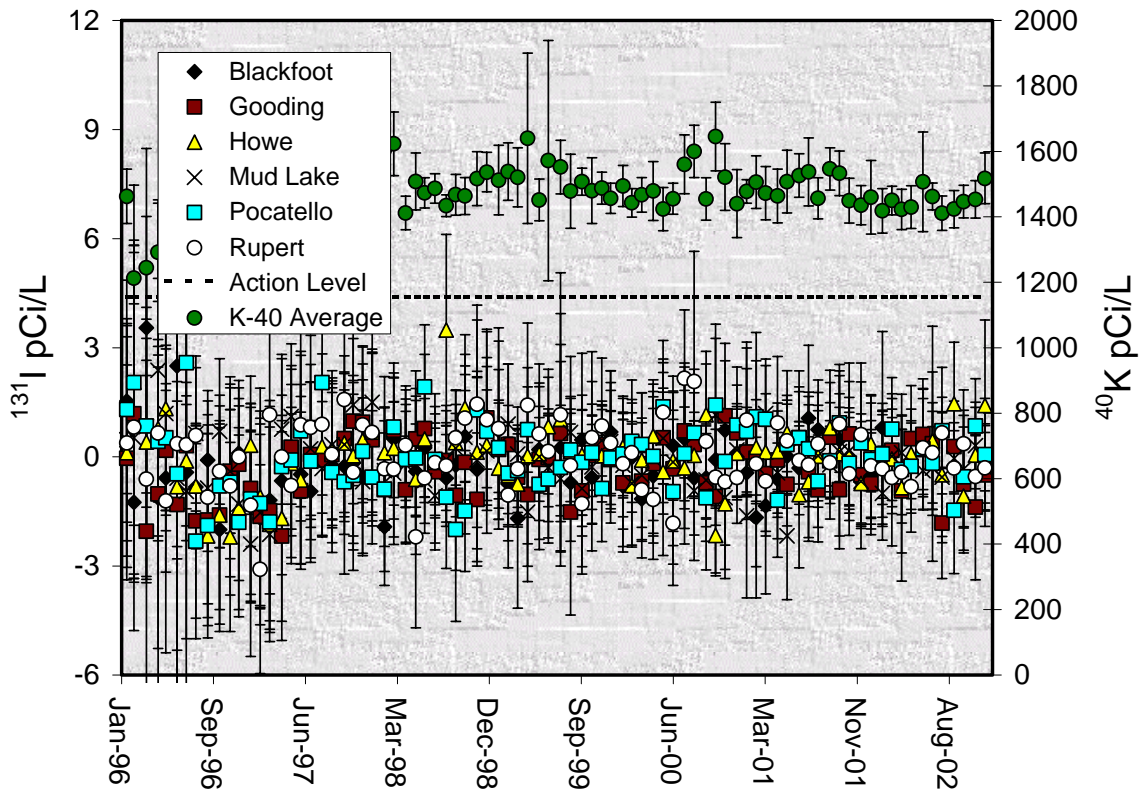


Figure 4-2. Reported concentrations of iodine-131 (primary y-axis) in milk samples collected by INEEL OP since 1996. The action level corresponds to a committed dose equivalent (CEDE) of 50 μ Sv/y (5 mrem per year) to the thyroid of an infant assuming a constant iodine-131 concentration. The average potassium-40 concentrations (secondary y-axis) are shown to demonstrate the consistency in measurements since 1998. The iodine-131 error bars correspond to 2-sigma counting uncertainty and the potassium-40 error bars represent 1-standard deviation.

Table 4-1. Descriptive statistics for routine monthly milk samples collected by INEEL OP

| | ¹³¹ I in Milk (pCi/L) | ⁴⁰ K in Milk (pCi/L) |
|----------------------------|-------------------------------------|------------------------------------|
| Average: | -0.14 | 1454 |
| Median: | -0.19 | 1445 |
| Standard Deviation: | 0.65 | 84 |
| Minimum: | -1.82 | 1277 |
| Maximum: | 1.46 | 1729 |
| Number of Routine Samples: | 60 | |

Soil Sampling

Long-term radiological conditions are monitored by identifying and measuring gamma-emitting radionuclides in soil at locations on the INEEL, near the INEEL boundary, and at distant locations with respect to INEEL. Monitoring concentrations of gamma-emitting radionuclides in surface soil provides insight to the transport, deposition, and accumulation of radioactive material in the environment as a result of INEEL operations and historic atmospheric testing of nuclear weapons.

INEEL OP uses a combination of monitoring techniques including soil sampling and *in-situ* gamma spectrometry. The *in-situ* gamma spectrometry technique is preferred over soil sampling since this is a non-destructive analysis involving no sample collection or preparation. Therefore, no damage or alteration is done to the monitoring location and minimal waste generated.

When soil samples are collected, samples are taken in such a manner to minimize cross-contamination, obtain a representative sample, and disturb as little soil surface as possible. A composite of five individual samples is collected at each location for surface samples (sample depth between 0 and 5 cm) and subsurface samples (sample depth between 5 and 10-cm). Care is taken to minimize contamination between the two sampling depths.

During 2002, soil samples were collected at seven locations. To minimize the generation of excess sample media, soil samples were prepared in the field for gamma spectroscopic analysis at ISU EML. Sample containers (“pucks”) were weighed and labeled at the Idaho Falls office prior to going to the field.

Upon arrival at the sampling station, the location was identified using a Global Positioning System (GPS). Five soil samples were collected at each monitoring location for surface samples using a 10-cm (4-inch) diameter ring. Soil samples were sieved using a #10 sieve to obtain a homogeneous particle size distribution. The composite sample was then thoroughly mixed and an aliquot was placed in a clean sample container and labeled. The samples were weighed when they were returned to the office in Idaho Falls.

Five more soil samples were collected at each monitoring location for subsurface samples. Subsurface soil samples were also sieved and thoroughly mixed. An aliquot was placed in a clean sample container and labeled. The sample was weighed when samples were returned to the office in Idaho Falls. Gamma spectroscopic analysis results of soil samples collected during 2002 were provided in the INEEL OP ESP data report for the third calendar quarter of 2002.

***In-Situ* Soil Monitoring**

Measurement of gamma-emitting radionuclides *in-situ* has become feasible with the advent of the intrinsically high-purity germanium detector (HPGe) and portable multi-channel analyzer (MCA). Data collected using the HPGe and digital MCA offers an opportunity to quickly set up the detection system in the field and still make accurate and reproducible measurements. Data are stored electronically until they can be downloaded to a personal computer for spectral analysis.

In-situ gamma spectrometry is performed using a HPGe set on a tripod to fixed height of 1-m above the ground surface. Using basic assumptions (e.g., soil density, radionuclide distribution), a soil concentration can be estimated based upon instrument response using energy dependence and angular response.

Descriptive statistics for *in-situ* gamma spectrometry are found in **Table 4-2**. Assumptions used for *in-situ* gamma spectroscopy include a 1.5-g/mL soil density, a field of view with a 10-m radius, and homogeneous radionuclide distribution in the top 5-cm of soil.

Table 4-2. Descriptive statistics of *in-situ* gamma spectrometry measurements of cesium-137 in soil. All measurements in picocuries per gram (pCi/g)

| | Boundary | Distant | Onsite |
|----------------------|----------|---------|--------|
| Number of Locations: | 9 | 6 | 40 |
| Average: | 0.4 | 0.4 | 0.5 |
| Median: | 0.4 | 0.6 | 0.5 |
| Standard Deviation: | 0.2 | 0.2 | 0.2 |
| Minimum: | 0.1 | 0.1 | 0.0 |
| Maximum: | 0.6 | 0.6 | 0.9 |

Other man-made radionuclides were also identified via *in-situ* gamma spectrometry. Americium-241 was measured at a location near the Radioactive Waste Management Complex (RWMC) at concentrations near the detection capability of the detector (0.41 ± 0.20 pCi/g, MDC: 0.34 pCi/g). This measurement is less than 5 percent of the recommended screening limits for arid, rural, sparsely vegetated areas identified in Table 2.1 of NCRP Report Number 129³. Cobalt-60 was measured at six locations near the Test Reactor Area (TRA). These measurements were on the INEEL and fell between 4 percent and 11 percent of the recommended screening limits for arid, rural, sparsely vegetated areas identified in Table 2.1 of

³ National Council on Radiation Protection and Standards, "Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies," NCRP Report Number 129, January 1999.

NCRP Report Number 129 for ^{60}Co . *In-situ* gamma spectroscopic monitoring results of soil performed during 2002 were provided in the INEEL OP Environmental Surveillance Program data report for the third calendar quarter of 2002.

Interprogram Comparisons of Terrestrial Monitoring Results

Soil Sampling Conducted with ESER

During July 2002, INEEL OP collected ten soil samples with ESER. INEEL OP collected and prepared soil samples in the field to minimize impact to the soil sampling location and to minimize waste generation. Five surface soil samples (0 to 5-cm depth) and five shallow sub-surface soil samples (5 to 10-cm depth) are collected at each location. Samples are placed in a “puck” sample container and analyzed via gamma spectroscopy at ISU EML. Excess soil is returned to the collection sites when the sample is collected.

ESER collects soil samples in a similar fashion, but prepares the samples in the laboratory using a different preparation procedure. Like INEEL OP, ESER collects five surface soil samples (0 to 5 cm depth) and five shallow sub-surface soil samples (5 to 10-cm depth) which are collected as a composite sample at each location. The samples are taken to a laboratory for sample preparation. At the laboratory, the samples are dried in an oven to remove any moisture, mixed, and then passed through a sieve to ensure a homogeneous mixture. Samples are then placed in a 500-mL Marinelli beaker and analyzed via gamma spectroscopy at ISU EAL and analyzed via radiochemical separation at a contract laboratory.

Table 4-3. Descriptive statistics and comparison results of soil samples collected at co-located locations (ESER and INEEL OP). All values given in pCi/g.

| | INEEL OP Cesium-137 | ESER Cesium-137 | INEEL OP Potassium-40 | ESER Potassium-40 |
|--|------------------------|--------------------|--------------------------|----------------------|
| Average: | 0.41 | 0.51 | 17.9 | 15.3 |
| Median: | 0.42 | 0.46 | 17.9 | 14.9 |
| Standard Deviation: | 0.27 | 0.29 | 4.4 | 3.4 |
| Minimum: | 0.05 | 0.11 | 11.2 | 11.0 |
| Maximum: | 1.02 | 1.27 | 26.3 | 21.0 |
| Number of Paired Samples: | 14 | | 14 | |
| Percent Agreement (Relative Difference): | 50.0% | | 100.0% | |
| Percent Agreement (3-sigma): | 35.7% | | 57.1% | |
| Average Relative Difference: | -14.5% | | 7.6% | |

Analytical results for cesium-137 show relatively poor agreement and the results for potassium-40 show relatively good agreement for soil samples collected by INEEL OP and ESER. The results of this comparison and comparative descriptive statistics are shown in **Table 4-3**. At two of the soil sampling locations used by ESER, INEEL OP used *in-situ* gamma spectrometry to determine concentrations of cesium-137 and potassium-40 shown in **Table 4-3**.

***In-Situ* Measurements Conducted with BBWI**

During the summer of 2002, INEEL OP performed an independent, semi-empirical efficiency calibration of its high-purity Germanium (HPGe) detectors used for *in-situ* gamma spectrometry. INEEL OP used a 55 percent relative efficiency⁴ “p-type” HPGe detector and a 95 percent relative efficiency “n-type” HPGe detector. The signal produced by the detector is collected using a digital multi-channel analyzer (MCA) that provides high-voltage to the detector as well as electronically storing all spectra collected. Gamma spectra collected at the various monitoring locations are closely examined for gamma energies attributable to man-made radionuclides. Once radionuclides are identified, the signal measured by the HPGe is compared to the instrument’s efficiency calibration and soil concentrations for the radionuclides are estimated.

Several *in-situ* soil measurements were made near INEEL facilities during 2002. The results of the comparison of these data and the descriptive statistics of this comparison are shown in **Table 4-4**.

Table 4-4. Descriptive statistics of co-located *in-situ* gamma spectroscopic results for cesium-137 performed by BBWI and INEEL OP during 2002. All values given in pCi/g.

| | BBWI | INEEL OP GMX | INEEL OP P-type |
|---|-------|-----------------|-----------------|
| Average: | 0.59 | 0.51 | 0.49 |
| Median: | 0.56 | 0.54 | 0.52 |
| Standard Deviation: | 0.14 | 0.19 | 0.14 |
| Minimum: | 0.34 | 0.02 | 0.12 |
| Maximum: | 0.90 | 0.90 | 0.84 |
| Number of Locations Used for Comparison: | 30 | 25 | 24 |
| Average Relative Difference (BBWI v INEEL OP GMX N-type): | 10.6% | | |
| Average Relative Difference (BBWI v INEEL OP P-type): | 8.4% | | |
| Average Relative Difference (GMX N-type v P-type): | -5.8% | | |
| Percent in agreement (BBWI v INEEL OP GMX N-type): | 80.0% | | |
| Percent in agreement (BBWI v INEEL OP P-type): | 79.2% | | |
| Percent in agreement (INEEL OP GMX N-type v P-type): | 89.5% | | |

References:

US Nuclear Regulatory Commission, Regulatory Guide 1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I, Revision 1, October 1977.

National Council on Radiation Protection and Standards, “Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies”, NCRP Report Number 129, January 1999.

⁴ Relative efficiency with respect to a 3 x 3-inch NaI(Tl) scintillation detector for ⁶⁰Co.

Chapter 5

Water Monitoring

Major Findings and Developments:

Tritium, gross beta radioactivity, strontium-90, and chromium exceeded drinking water standards in the Eastern Snake River Plain Aquifer beneath several facilities at the INEEL. Contaminant concentrations generally decreased or remained constant through 2002, based on samples from INEEL OP water surveillance locations.

- Drinking water standards were not exceeded at any sites where water is used by the public or INEEL workers.
- No contamination attributable to the INEEL was identified in samples collected at distant or Magic Valley monitoring sites, however, INEEL impacts can be identified at some sites along the southern boundary of the INEEL. Tritium concentrations at these sites were greater than background but less than 1 percent of drinking water standard. Chromium at these wells also exceeded background but was less than 5 percent of the drinking water standard.
- Analytical results from INEEL OP monitoring were generally in close agreement with results reported by the USGS and ESER.

Primary Nonradiological Results and Trends

Water samples collected by the INEEL OP in 2002 from distant or Magic Valley locations did not exhibit concentrations of nonradiological contaminants indicative of impacts from the INEEL. Similarly, the majority of analyses on samples collected from boundary wells detected only concentrations reflecting background or non-INEEL anthropogenic influences. However, common ions, nutrients, or trace metals attributable to INEEL impacts were detected in some boundary wells, as well as in several onsite wells. **Table 5-1** compares the minimum and maximum concentrations of nonradiological constituents to their respective background estimations and any applicable drinking water standards as defined by the U.S. EPA Safe Drinking Water Act.

INEEL OP detected calcium, sodium, potassium, chloride, sulfate, nitrate plus nitrite, total phosphorous, barium, chromium, zinc, gross beta radioactivity, and tritium above background concentrations at some sites on the INEEL. Additionally, strontium-90 and technetium-99, which are beta-emitting radionuclides that were historically disposed of to the aquifer at the INEEL, were detectable in samples from at least two INEEL OP onsite locations. A brief summary of these analytes is presented here. A more complete discussion of surveillance monitoring results for 2002 and historical trends for selected nonradiological and radiological analytes is presented in “Environmental Surveillance Program Water Quality Trends for Surveillance Monitoring Sites, 1994 - 2002 Data” (Hall, 2003b).

Table 5-1. Summary of selected nonradiological INEEL OP water surveillance analytical results, 2002

| | Range of Concentrations | | | | | Background ^a Concentrations for the Snake River Plain Aquifer | Drinking Water Standard | |
|--|-------------------------|-----|--|--------------|-----|--|-------------------------------|------------------------|
| Analyte | Sites on the INEEL | | Boundary, Distant and Surface water sites | | | | | |
| | Min | Max | Median | Min | Max | | | Median |
| Common Ions/Nutrients (mg/L) | | | | | | | | |
| Calcium | 34.0 – 87.9 | | 45.6 | 9.0 – 57.4 | | 41.2 | 5 – 43 | None ^b |
| Magnesium | 12.4 – 26.0 | | 16.6 | 2.7 – 19.7 | | 15.6 | 1 – 15 | None |
| Sodium | 7.6 - 49 | | 15 | 5.2 – 34 | | 11.9 | 5 – 14 | None |
| Potassium | 1.2 – 6.1 | | 3.1 | 1.0 – 6.5 | | 2.7 | 1 – 3 | None |
| Chloride | 7.5 - 122 | | 18.4 | 3.9 – 42.4 | | 13.8 | 2 – 16 | SMCL ^c =250 |
| Sulfate | 19.1 - 160 | | 27.3 | 8.0 – 56.6 | | 22.6 | 2 – 24 | SMCL=250 |
| Total Nitrate plus Nitrite (as nitrogen) | 0.446 – 3.93 | | 1.365 | 0.244 – 1.99 | | 0.803 | 1-2 | MCL ^d =10 |
| Total Phosphorus | 0.007 – 0.026 | | 0.016 | 0.008 – 0.27 | | 0.014 | <0.02 | None |
| Trace Metals (µg/L) | | | | | | | | |
| Barium | 29 - 165 | | 49 | 18 – 76 | | 35 | 50 – 70 | MCL=2000 |
| Chromium | 5 - 137 | | 10 | 5 – 8 | | 6 | 2 – 3 | MCL=100 |
| Zinc | 2- 620 | | 45 | 10 – 232 | | 88 | <10 | SMCL=5000 |
| Manganese | <2 - 3 | | 2 | <2 - 36 | | <2 | <1 – 4 | None |
| Lead | <5 – 9 | | <5 | <5 | | <5 | <5 | AL ^e = 15 |
| ^a Background is defined as ambient conditions for sites with no obviously anthropogenic influence. The range given is from Knobel and others (1992), or defined by the minimum and median from Knobel and others (1999). ^b Not applicable, no standard set ^c Secondary maximum contaminant level ^d Maximum contaminant level ^e Action level | | | | | | | | |

A synopsis of the water surveillance sampling locations, schedules, analyses, and procedures specific to the INEEL OP water monitoring strategy appears in **Chapter 2**.

Common Ions and Nutrients

Calcium, magnesium, sodium, potassium, chloride, sulfate, total nitrate plus nitrite as nitrogen, and total phosphorus were detected in some groundwater samples collected on the INEEL at concentrations believed to represent contamination from activities on the site. These ions, along with a form of carbonate ions, constitute a majority of the dissolved components of natural groundwater (“major ions”), and can vary due to differences in geology of aquifer recharge areas (Hall, 2000). Concentrations of these ions can also vary due to anthropogenic influences such as evaporation of infiltrating irrigation water or injection or infiltration of wastewaters. Water quality trends for 2002 monitoring and results are given in Hall (2003b).

Calcium

Calcium concentrations at several onsite wells (CFA 1, CFA 2, USGS 65, USGS 85, and USGS 112) exceeded the expected background range for the aquifer estimated from data published by Knobel and others (1992) (see **Table 5.1** for range of concentrations observed for onsite, and boundary and distant locations). Calcium is not identified as a major component of INEEL wastewater. However, the elevated concentration and similarity in historical trends of calcium and some other major ions in groundwater (magnesium, potassium, sodium and chloride) to major waste components which include chloride, sulfate, and sodium suggest that the elevated calcium values observed are disposal-related for the identified onsite wells. Calcium concentrations for samples from onsite locations increased slightly in 2002 for some wells; this is probably due to historical variability in disposal.

Concentrations for calcium, as well as magnesium, chloride, nitrate plus nitrite, sulfate, and barium were elevated as compared with historical results in the April 2001 sample from upgradient well P&W 2. This well was not sampled again until April 2002. At that sampling, concentrations for all constituents monitored returned or approached historical trends, suggesting that whatever impacted this well was a transient event. Further discussion is presented in Hall (2002a).

Magnesium

Magnesium concentrations in samples from onsite wells exceed the expected background range for onsite wells CFA 1, CFA 2, USGS 65, and USGS 112, with CFA 2 having the highest concentrations. Magnesium and calcium results follow similar trends for CFA 1 and CFA 2, and for USGS 65 and USGS 112. Magnesium, as with other major ions, is a natural constituent of groundwater beneath the INEEL. Although not identified as an INEEL waste constituent, the elevated concentrations of magnesium reflect trends observed for other major ions and are likely reflective of INEEL waste disposal. Magnesium concentrations are unchanged from 2001 results.

Sodium

Sodium is identified as a major waste constituent for INEEL facilities, with concentrations for wells CFA 1, CFA 2, USGS 85, and USGS 112 reflecting this waste disposal influence. The highest concentrations are observed in well USGS 112, with historical trends similar to chloride and to most other major ions for CFA 1 and CFA 2. Concentrations for samples from onsite locations declined about 10 percent from 2001. In general, the boundary, distant, and surface water samples yielded sodium concentrations within background levels.

Potassium

A drinking water standard has not been established for potassium. Concentrations of dissolved potassium in groundwater samples are typically less than 4 mg/L. These concentrations vary as a result of natural variability, waste disposal at the INEEL, or other anthropogenic influences.

Potassium concentrations from onsite wells USGS 112, CFA 1, and CFA 2 are not significantly greater than the expected background levels, but as trends for potassium tend to mirror trends for sodium and other known INEEL wastes, it is likely that at least some portion of the potassium present is due to past disposal activities at INTEC. Potassium concentrations remained relatively unchanged from 2001.

The potassium concentrations were highest for the Mud Lake water supply well and USGS 27, likely due to natural variability for Mud Lake water supply well, and a combination of natural variability and some non-INEEL anthropogenic influences for USGS 27.

Chloride

The secondary maximum contaminant level (SMCL) for chloride, historically a major constituent of INEEL chemical wastes, is 250 mg/L. Elevated chloride may also indicate influence from surface water, irrigation, or other anthropogenic impacts (Hem, 1985).

Chloride concentrations for onsite wells USGS 112, 115, 85, CFA 1, and CFA 2 exceeded the background range, with the highest values found in samples from USGS 112, at about half the SMCL. Since 1997, chloride concentrations for USGS 112 have declined about 30 percent. Chloride levels for the onsite locations listed, as well as USGS 85, are likely impacted by INEEL waste disposal. Overall, onsite chloride concentrations have declined about 10 percent since 2001.

Alpheus Springs, Clear Springs, and the Minidoka water supply (locations distant from the INEEL) exceeded the background range for chloride. Other constituents (sodium, nitrate plus nitrite as nitrogen) suggest that Alpheus and Clear Springs have some degree of impact due to nearby anthropogenic sources such as irrigation. This is supported by tritium levels, which reflect levels observed in surface water for other INEEL OP monitoring. Minidoka water supply chloride concentrations are likely due to natural sources, with no indication of impact from INEEL activities or other anthropogenic sources.

Sulfate

No wells sampled exceeded the SMCL of 250 mg/L for sulfate, historically a major INEEL waste constituent. Elevated sulfate can also be an indication of impacts from surface water, irrigation, or other anthropogenic impacts.

Sulfate concentrations were highest in samples collected from USGS 65, where water quality has been impacted by waste disposal at TRA. Concentrations from samples for wells USGS 112, 85, 87, 120, 104, CFA 1, CFA 2, and RWMC Production all exceeded the background range for sulfate, with trends for sulfate similar to calcium and magnesium. Concentrations for these wells are likely due to INEEL waste disposal, and are unchanged for 2002.

Alpheus Springs, and Clear Springs sulfate concentrations were highest for boundary, distant, and surface water samples. These sulfate results along with chloride concentrations are attributable to a combination of local anthropogenic influences.

Nitrate Plus Nitrite As Nitrogen

The MCL for nitrate plus nitrite (as nitrogen) is 10 mg/L, with concentrations greater than 1-2 mg/L indicating anthropogenic impacts to groundwater of the Eastern Snake River Plain Aquifer (Rupert, 1994, 1997).

Nitrogen concentrations are elevated for seven onsite locations, and greatest for wells CFA 1, CFA 2, and USGS 112. Elevated concentrations at these and other sites (USGS 65, 85, 115, and 100) are the result of past wastewater disposal at INTEC and TRA. The highest concentration detected in groundwater is from well CFA 2. Concentrations for CFA 1 and USGS 112 declined, while concentrations for the remaining onsite locations remained constant. The upgradient site USGS 27 likely shows agricultural impacts.

Concentrations for boundary, distant, and surface water sites were all within the 1-2 mg/L background range. Alpheus Springs and Shoshone water supply, already discussed as having concentrations of other constituents indicative of anthropogenic impacts, were near the upper background range.

Total Phosphorus as P

Total phosphorous as P exceeded the background levels in two wells, USGS 112 and USGS 85. The median result for sample sites on the INEEL was similar to distant, boundary, and surface water sites. Concentrations for onsite locations remained unchanged from 2001 sample results.

The highest values were from a boundary location, the Mud Lake water supply. This higher concentration is indicative of local hydrogeologic conditions, as other indicators of anthropogenic influences are absent at this well (such as low nitrate plus nitrite and very low tritium).

Trace Metals

Groundwater samples collected by INEEL OP in 2002 were analyzed for barium, chromium, zinc, lead, and manganese. Chromium and barium can be directly linked to INEEL waste disposal activities. Concentrations of zinc, lead, and manganese may be related to well construction materials, natural concentrations, as well as anthropogenic INEEL sources.

Barium

In all 2002 water samples, barium concentrations were considerably lower than the MCL of 5,000 µg/L. Barium was detected in all samples collected from INEEL sites, with the highest concentrations being reported for USGS 112. Barium was above background levels for CFA 1, CFA 2, and USGS 85. Barium has historically been a waste product from INTEC. Trends observed for CFA 1, CFA 2, and USGS 85 reflect those of most other known INEEL waste constituents (e.g., sodium and chloride), with concentrations unchanged from 2001.

Barium concentrations for boundary, distant, and surface water sites were highest for samples collected from the Big Lost River and lowest for sites on the eastern side of the INEEL. The distribution for sites not influenced by the INEEL may provide information on recharge areas for groundwater.

Chromium

The primary source of chromium contamination at the INEEL is TRA, where it was used as a corrosion inhibitor until 1972. Lesser amounts of chromium, used for the same purpose, were disposed of at INTEC and other INEEL facilities (Frederick and others, 1998). Chromium concentrations for samples from USGS 65 located south of TRA exceeded the MCL of 100 µg/L.

Samples for other INEEL sites, RWMC Production, USGS 85, 87, CFA 1, CFA 2, and USGS 115, exceeded background. Other sites, USGS 104, 103, 108, 112, and 14, also show results greater than background. Monitoring results suggest the chromium background in the vicinity of the INEEL may be greater than the published range of 2-3 µg/L (Knobel and others, 1992). Chromium in excess of about 6-7 µg/L for samples from onsite locations down gradient from TRA-INTEC is likely due to historical waste disposal. Chromium concentrations for USGS 65 have decreased consistently, declining about 30 percent since 1994 and about 5 percent in 2002.

Chromium concentrations for boundary, distant, and surface water sites were less than 7 µg/L. All surface water and distant sites were at or less than the detection level. Concentrations for boundary sites USGS 14, 103, 104, 108, 124, and 125 may indicate INEEL impacts, contamination from well materials, or natural variations in background.

Zinc, Lead and Manganese

A clear relationship between a disposal point, distribution within the aquifer, and historical contaminant trends does not appear to exist for zinc, lead, and manganese.

Zinc concentrations were less than the secondary MCL (5,000 µg/L) with the highest zinc concentrations observed in samples from USGS 115. Most other INEEL wells returned detectable levels of zinc. Wells with detectable zinc tend to have dedicated submersible pumps installed in them. Thus, some degree of zinc contamination may be related to the well construction and the type of pump installed in the well.

Historically, lead and manganese have been measured in some INEEL waste streams (Frederick and others, 1998) and detected in a limited number of INEEL monitoring wells. Lead was detected in samples from two wells on the INEEL, USGS 100 and 104 (8.5 µg/L and 6 µg/L). Manganese was detected at six sites. Three of the sites are on the INEEL (CFA 2, USGS 27 and 87) and the remainder (USGS 124, 125, and Mud Lake water supply) are boundary or upgradient sample locations. Manganese concentrations ranged from the detection level of 2 µg/L to 7 µg/L for onsite and boundary locations and 36 µg/L for the Mud Lake water supply. While both of these contaminants are or have been present in INEEL wastewater, concentrations are within that reported by others for the Eastern Snake River Plain Aquifer (Wood and Low, 1988) and are likely due to natural variability or anthropogenic influences at the well, such as well construction materials or foreign materials known to be present in the well (Hall, 2003a).

Primary Radiological Results and Trends

Water samples were collected by the INEEL OP and analyzed for gross alpha and gross beta radioactivity, gamma-emitting radionuclides, and tritium. Samples from selected sites were also collected and analyzed for strontium-90 and technetium-99. **Table 5-2** summarizes INEEL OP's radiological results for water sampling.

Gross Radioactivity

Water samples collected from all sample sites are analyzed for gross alpha and gross beta activity. Gross measurements are primarily a screening tool used to identify whether or not more specific analyses are needed. As samples for these gross measurements are collected at all monitoring sites, they provide a means of determining overall variability. Where these gross measures exceed expected ranges, or historical sampling has indicated the presence of alpha- or beta-emitting radionuclides, radiochemical analyses are completed.

Table 5-2. Summary of selected radiological INEEL OP water surveillance analytical results, 2002

| Analyte | Range of Concentrations (pCi/L \pm 2s) | | | | | | Background Concentration for the Snake River Plain Aquifer | Drinking Water Standard |
|---|--|-----------------|----------------|---|---------------|---------------|--|-------------------------|
| | Sites on the INEEL | | | Boundary, Distant and Surface water sites | | | | |
| | Min | Max | Median | Min | Max | Median | | |
| Gross Alpha (as Thorium-230) ^{a,c} | <MDC | 4.4 \pm 2.3 | <MDC | <MDC | 4.2 \pm 2.3 | <MDC | 0 – 3 | 15 |
| Gross Beta (as Cesium-137) ^{a,c} | <MDC | 52.6 \pm 2.1 | 2.3 \pm 0.9 | <MDC | 5.5 \pm 1.0 | 2.3 \pm 0.8 | 0 – 7 | 50 ^b |
| Cesium-137 ^c | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC | 0 | 200 ^b |
| Tritium ^c | <MDC | 12150 \pm 240 | 1205 \pm 95 | <MDC | 170 \pm 90 | <MDC | 0 – 40 | 20,000 |
| Tritium ^{c,d} | <MDC | 102 \pm 8 | 17 \pm 6 | <MDC | 183 \pm 9 | 22 \pm 6 | 0 – 40 | 20,000 |
| Strontium-90 ^c | <MDC | 16.4 \pm 3.1 | 2.83 \pm 0.7 | | N/A | | 0 | 8 ^b |
| Technetium-99 ^c | <MDC | 44.7 \pm 0.7 | 5.4 \pm 0.4 | | N/A | | 0 | 900 ^b |

^a The terms “as thorium-230” and “as cesium-137” refer to the radionuclide used to calibrate the instrument and do not imply that the activities present are due to the presence of these specific radionuclides.

^b Expressed as a cumulative annual dose of 4 millirem/year. For unspicuated gross beta, 50 pCi/L is used as an action level; a activity-concentration is calculated for specific nuclides; e.g., for cesium-137, 4 millirem is equivalent to 200 pCi/L, if cesium-137 were the only detectable radionuclide.

^c MDC for gross alpha and gross beta radioactivity is approx. 2.5 and 1.4 pCi/L cesium is typically >6 pCi/L, tritium by standard analysis methods is 160 pCi/L and tritium by enhancement method is 10-15 pCi/L. The MDC for strontium-90 is approx. 1.5 pCi/L. The MDC for technetium-99 analyzed by the contract lab is 4-9 pCi/L (total or unfiltered), and 0.5 pCi/L for dissolved technetium-99 analyzed by ISU-EML.

^d Tritium analyzed using an Electrolytic Enhancement Method. For onsite locations, this includes just those samples that did not exceed MDC for tritium by the standard method.

Gross Alpha Radioactivity

Results for samples from 23 locations during 2002 exceeded the MDC (approximately 2.5 pCi/L) for gross alpha radioactivity. All results were well below the MCL of 15 pCi/L.

Samples from seven onsite locations yielded detectable gross alpha, with the highest activity measured at about one third of the MCL. No gross alpha radioactivity trends are apparent for any monitored sites, including sites with gross alpha detections in 2002. Onsite gross alpha detections are attributable to naturally occurring radionuclides (uranium and thorium isotopes). Ten boundary, distant, and surface water sites and five Magic Valley sites also yielded detections.

Gross alpha radioactivity levels for all sites were within the range expected for naturally occurring radioactivity due to uranium and thorium decay products in the aquifer and illustrate the range of activity typical for the Eastern Snake River Plain.

Gross Beta Radioactivity

Results for samples from all but four onsite, boundary, distant, and Magic Valley locations during 2002 contained gross beta radioactivity exceeding the MDC of approximately 1.4 pCi/L.

Drinking water MCLs are based on an exposure limit equivalent to 4 millirem per year to the whole body, with a screening level of 50 pCi/L for gross beta radioactivity. Strontium-90, an INEEL contaminant present in groundwater down gradient from INTEC, decays primarily with beta particles and has an MCL of 8 pCi/L.

Gross beta radioactivity concentrations for samples collected from onsite wells ranged from less than the MDC to 52.6 ± 2.1 pCi/L. The highest observed gross beta activities were from samples collected at observation wells USGS 112 and 85, where groundwater is known to have been impacted by historical waste disposal practices at INTEC. Gross beta concentrations for these sites have in general been declining since INEEL OP monitoring began in 1994, however, results for individual sampling periods tend to fluctuate. Gross beta radioactivity trends, along with trends for strontium-90, for sites USGS 85 and 112 are presented in **Figure 5-4**.

Gross beta radioactivity concentrations in samples collected from the boundary, distant, surface water, and Magic Valley sites ranged from less than the MDC to 5.5 ± 1.0 pCi/L. Concentrations for gross beta radioactivity across the Eastern Snake River Plain Aquifer can vary. Typical values range from less than the MDC to about 7 pCi/L (Knobel and others, 1992).

Gamma Spectroscopy

Gamma spectroscopy results are reported for cesium-137, potassium-40, and for any gamma-emitting isotope that might be detected. No cesium-137 results exceeded the MDC. In 2002, naturally occurring potassium-40 was reported as detected in samples from one site. The levels of potassium-40 detected are greater than that expected and appears to be an artifact of the analysis process. Approximately 0.01 percent of all potassium naturally consists of radioactive potassium-40, resulting in background concentrations for the aquifer of approximately 0 – 7 pCi/L, significantly less than the detection level for this isotope (100 – 130 pCi/L). Potassium-40 is the predominant radioactive component in most foods and human tissues (Eisenbud and Gesell, 1997). No other gamma-emitting radionuclides were identified.

Tritium

Tritium concentrations for onsite monitoring locations did not exceed the MCL of 20,000 pCi/L for any sample collected in 2002. Concentrations in onsite samples ranged from less than the MDC to $12,150 \pm 240$ pCi/L. Nine onsite wells yielded tritium concentrations above the approximately 160 pCi/L MDC. The highest tritium concentrations are from USGS 65. The other onsite locations with detectable tritium are USGS 112, 85, 115, CFA 1, CFA 2, RWMC Production, USGS 87, and 104.

Samples from one boundary site, USGS 124, exceeded the MDC for tritium. This site has historically been at or above the standard tritium MDC, and reflects INEEL tritium disposal. No other boundary, distant, or surface water site exceeded the standard tritium MDC. Background levels of tritium in the Snake River Plain Aquifer range from 0 to 40 pCi/L (Knobel and others, 1992).

The onsite wells with detectable tritium are down gradient from TRA-INTEC and are known to have been impacted by historical waste disposal. The median tritium concentrations for onsite wells decreased 28 percent from 2001 levels, while concentrations for individual sites either remained steady, or decreased up to 35 percent. Historical trends for locations USGS 65, 112, and 115 are presented in **Figure 5-1**. Concentrations for USGS 65 and 112 have each declined about 5 percent, while USGS 115 declined about 35 percent from 2001.

As seen in **Figure 5-2**, tritium concentrations in USGS 85 have a similar downward trend while concentrations at CFA 1 and CFA 2 have fluctuated. Concentrations for samples from RWMC production well and USGS 104 have declined 4-10 percent while tritium concentrations for USGS 87 have held steady for 2002, as shown in **Figure 5-3**.

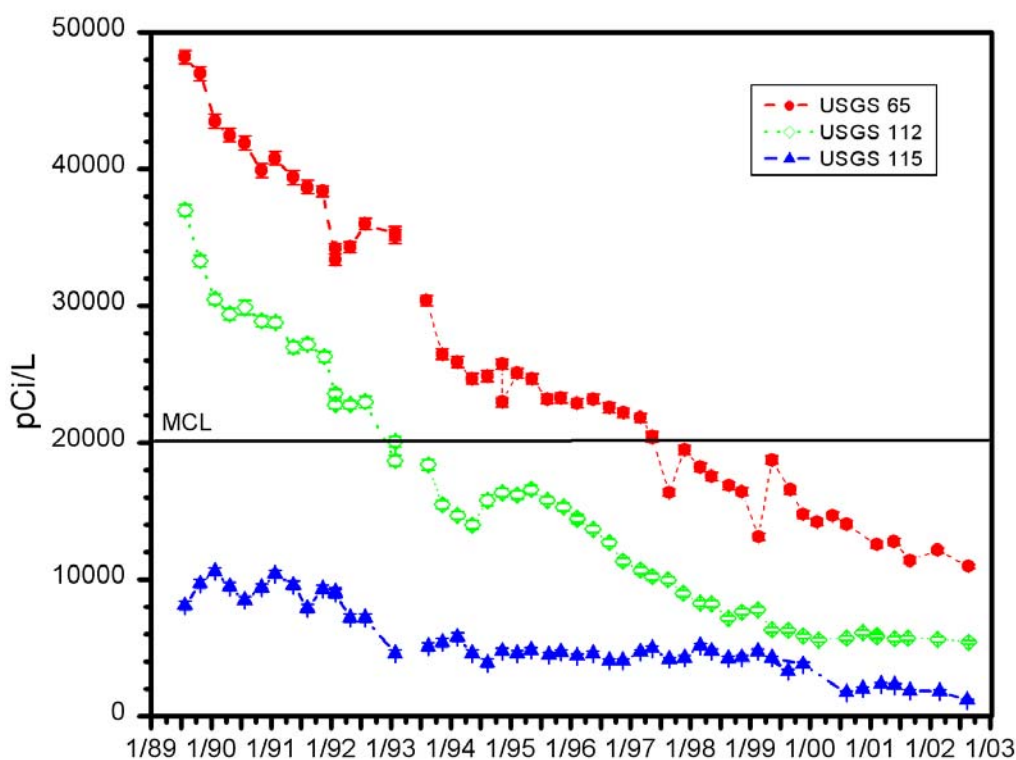


Figure 5-1. Tritium concentration over time, wells USGS 65, 112, and 115. Error bars are analytical uncertainty at 2 sigma.

An electrolytic enhancement technique was used to reanalyze samples that did not yield detectable tritium using the standard liquid scintillation analysis method. The MDC for this enriched or enhanced tritium analysis is about 10-15 pCi/L.

Onsite locations reanalyzed using the enhanced tritium method ranged from less than detectable levels to 102 ± 8 pCi/L, with a median concentration of 34 pCi/L. Samples from six onsite locations were reanalyzed. Results from one location, USGS 120, were clearly above expected

ambient concentrations with an average of 133 ± 9 pCi/L for samples from this site. The remaining sites, P&W 2, Site 14, USGS 19, USGS 27, and USGS 100, showed tritium concentrations within background levels.

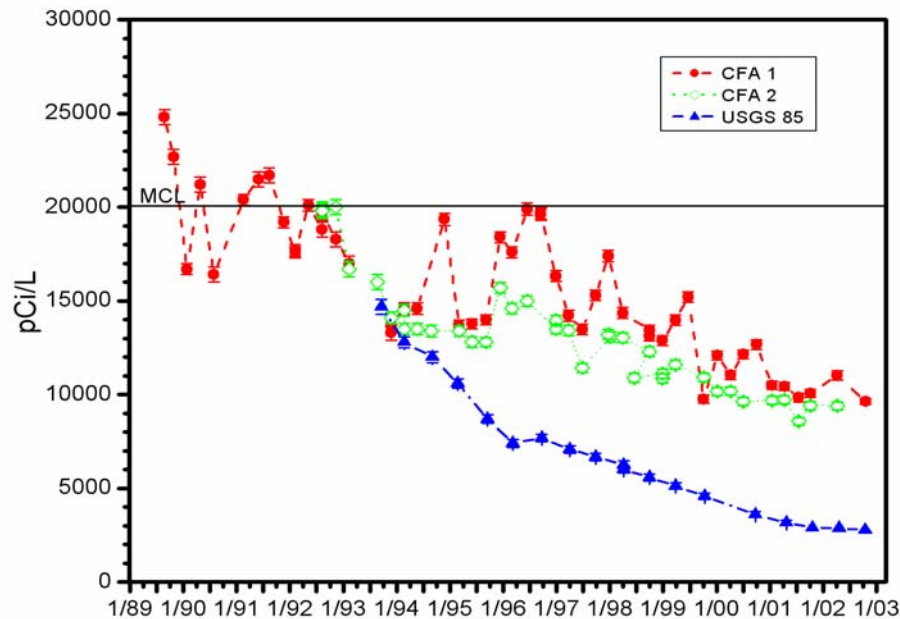


Figure 5-2. Tritium concentration over time, wells CFA 1, CFA 2, and USGS 85. Error bars represent 2-sigma uncertainty.

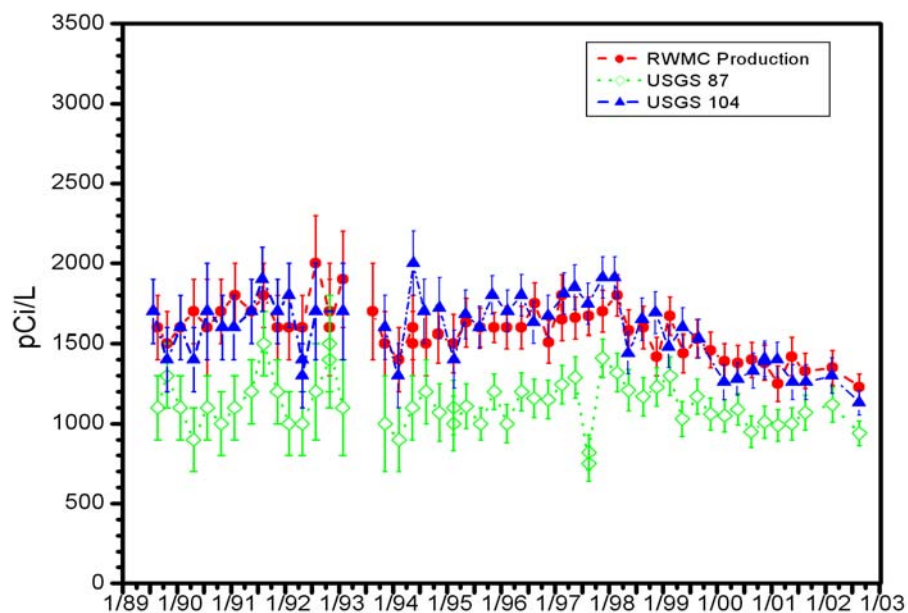


Figure 5-3. Tritium concentration over time, wells RWMC Production, USGS 87 and 104. Error bars represent 2-sigma uncertainty.

Enhanced tritium analysis of boundary sites USGS 103, 108, 124, 125, 11, and 14 all showed some degree of INEEL tritium contamination, while other boundary sites, USGS 8 and Atomic City, did not. Concentrations ranged from less than detection to 183 ± 9 pCi/L, with a median value of 19 ± 6 pCi/L. Tritium samples from USGS 108 and 124 showed results clearly greater than that expected for background conditions, with concentrations for these sites ranging from 183 ± 9 at USGS 124 to 105 ± 7 at USGS 108. Sites USGS 8, 11, and 14 showed detectable tritium concentrations ranging from 13 ± 6 to 35 ± 5 pCi/L. Historical sampling at USGS 11 and 14 has revealed the presence of INEEL contaminants, chlorine-36 and iodine-129, suggesting that tritium detected there is also a result of INEEL contamination. Tritium concentrations for USGS 8 have historically averaged about 40-50 pCi/L, consistent with concentrations observed for Big Lost River sites for previous years and other sites that are influenced by surface water or irrigation. Another boundary site, USGS 103, returned tritium concentrations just above sample-specific detection levels, at 11 ± 5 and 13 ± 4 pCi/L. An exhaustive study by Busenburg and others (2001) suggests that water from this well is influenced in a small degree from INEEL waste disposal.

Low-level tritium results for distant sites Alpheus Springs and Shoshone water supply average 35 pCi/L and also show nitrate values 1.2 to 1.99 mg/L, indicative of some degree of influence by surface water and irrigation. The tritium values observed for distant sites overall ranged from less than the MDC to 42 ± 6 with a median result of 19 pCi/L.

Rupert (1997) suggests that when tritium concentrations exceed about 4.5 pCi/L for a specific site, some portion of that groundwater had been recharged since the advent of nuclear testing in the early 1950s. Differing degrees of mixing older and recent (post-1950's) water result in the range of natural tritium concentrations observed. The tritium concentrations should be less than the ISU-EML MDC for enhanced tritium analysis of groundwater in the central portion of the Eastern Snake River Plain Aquifer where sources of recent recharge are absent or minimal.

Strontium-90 and Technetium-99

Strontium-90 and technetium-99 are contaminants that were released from spent nuclear fuel when it was reprocessed at the INTEC and introduced to the aquifer through the INTEC injection well and possibly through the TRA Warm Waste Ponds.

Samples from four onsite wells were analyzed for strontium-90. At CFA 1 and CFA 2, strontium-90 was below the MDC of about 1 pCi/L. Results for wells USGS 85 and 112 for 2002 showed strontium-90 at 2.83 ± 0.70 to 16.4 ± 3.1 pCi/L. Trends for strontium-90 concentrations, wells CFA 1, CFA 2, USGS 85, and 112 are shown in **Figure 5-4**.

Samples were collected for both total (unfiltered) technetium-99, analyzed by radiochemistry methods, and for dissolved (filtered) technetium-99, analyzed by ISU-EML using ion-selective filter disks, for each location monitored. Samples were collected from six locations with concentrations by both methods combined ranging from less than the MDC (about 1-2 pCi/L for the ion-selective filter method and 3 to 9 pCi/L for the radiochemistry method) to 41 ± 10 pCi/L. The highest concentrations were measured in samples from well USGS 112 (12.6 ± 1.8 to 41 ± 10 pCi/L). Total technetium-99 trends for selected wells are shown in **Figure 5.4a**. A trend of

generally decreasing concentrations for strontium-90 for USGS 85 and 112 is apparent from Figure 5.4 and is consistent with the observed trend for tritium at these locations. Trends for technetium-99 for these same locations (USGS 85 and 112) do not reflect strontium-90 trends for prior to 2000, but do for concentration trends after 2000. Results for dissolved technetium-99 discussed in the following paragraph confirm this post-2000 trend. The difference between pre- and post 2000 trends may be indicative of a change in major sources for post-2000 technetium-99 and strontium-90 concentrations for USGS 85 and 112.

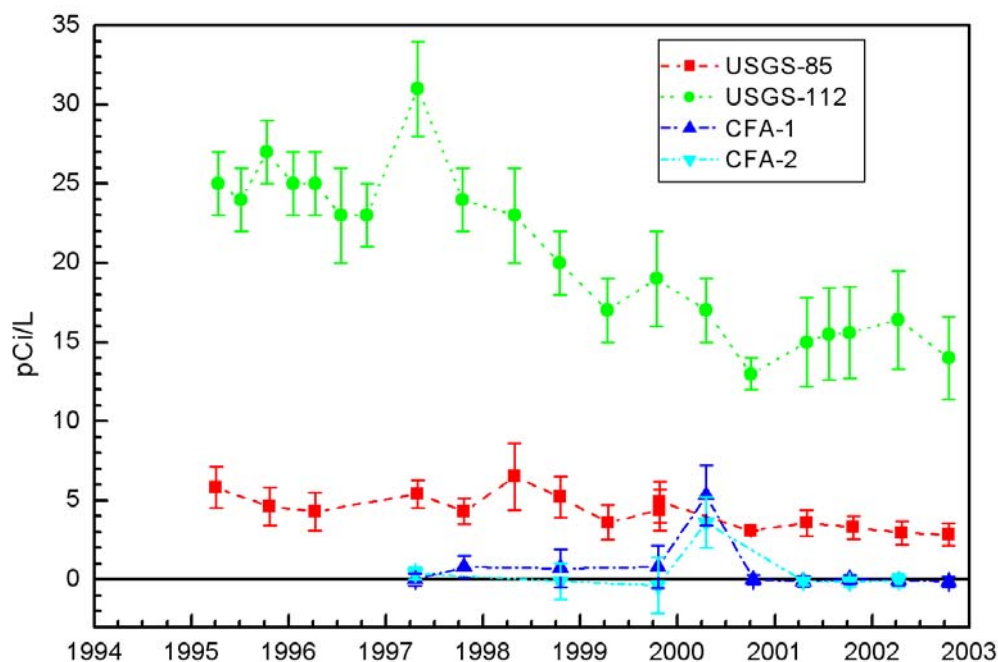


Figure 5-4. Strontium-90 concentrations for wells CFA 1, CFA 2, USGS 85, and 112

Technetium-99 was also detected in samples from USGS 85, 115, CFA 1, and CFA 2, with concentrations ranging from 2.0 ± 0.3 to 6.2 ± 0.3 pCi/L for these wells. The April 2002 sample for USGS-104 returned a detection with a concentration of 0.7 ± 0.3 pCi/L (compared to a sample-specific detection level of 0.4 pCi/L). The October 2002 sample from this well did not yield a detection. Historical trends for dissolved technetium-99 using the ion-selective filter method are shown in **Figure 5-4b**.

Samples were collected for analysis by both the radiochemistry and the ion-selective filter methods as a continuation of a special study conducted during 2000 by ISU-EML for analysis of technetium-99 (ISU-EML, 2000). Comparison of the radiochemistry and ion-selective filter technetium-99 results for locations where both a total, radiochemistry-method sample, and a dissolved, ion-selective filter sample were analyzed is presented in **Figure 5-4c**.

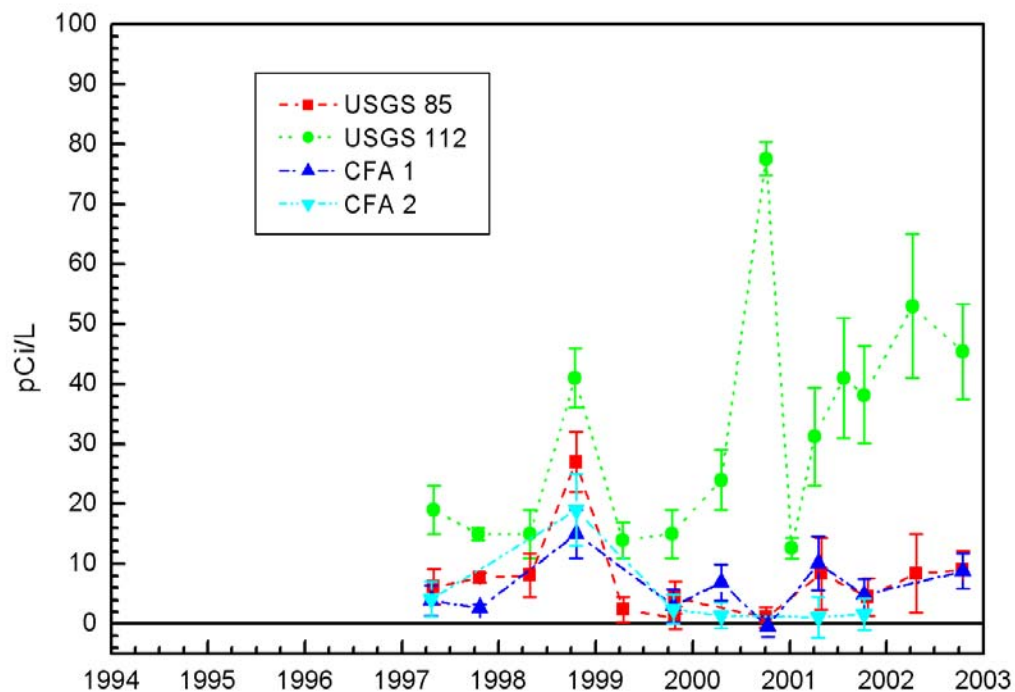


Figure 5-4a Total technetium-99 concentrations for wells CFA 1, CFA 2, USGS 85, and 112

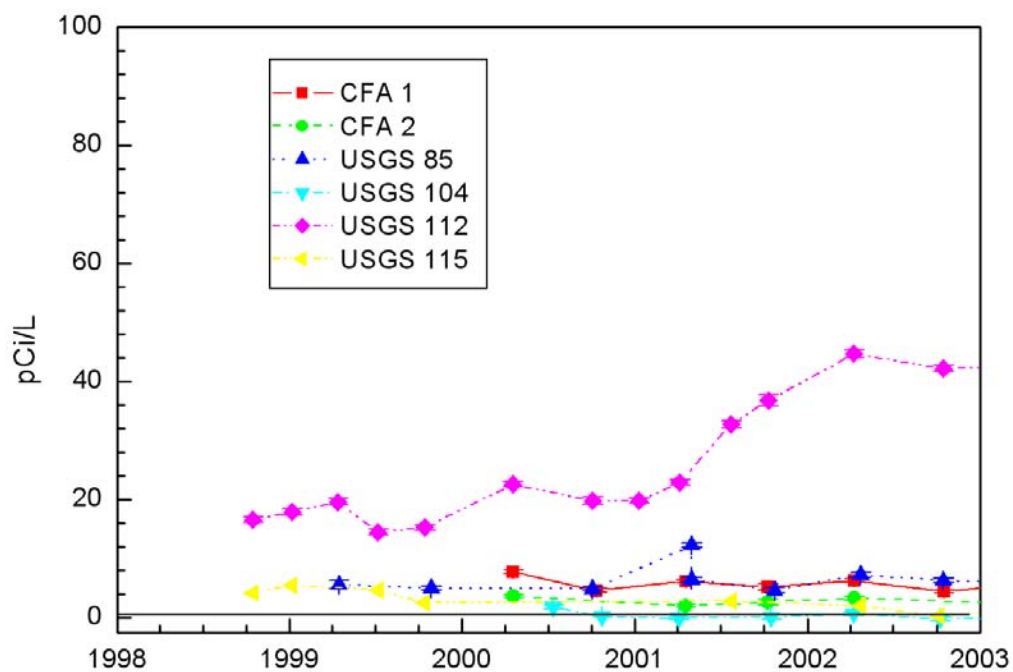


Figure 5-4b. Dissolved technetium-99 concentrations for wells CFA 1, CFA 2, USGS 85, 104, 112, and 115

A total of 23 paired-results from 2000-2002 were available for comparison. A liner regression completed for the dataset showed a slope of 1.26 ± 0.17 with a correlation coefficient (R) of 0.838, and an associated p-value for the slope of <0.0001 , indicating that the regression was meaningful (Refer to the section Interprogram Comparisons for more discussion of what constitutes a “meaningful” linear regression.). While most pairs of data were comparable, one pair, from USGS 112, October 2000 was not. The difference between these data, 77.6 ± 2.8 pCi/L for total technetium-99 and 19.8 ± 0.6 pCi/L for dissolved technetium-99, was investigated without an explanation being found. Dropping this pair from the regression yielded a slope of 1.16 ± 0.05 and R of 0.985.

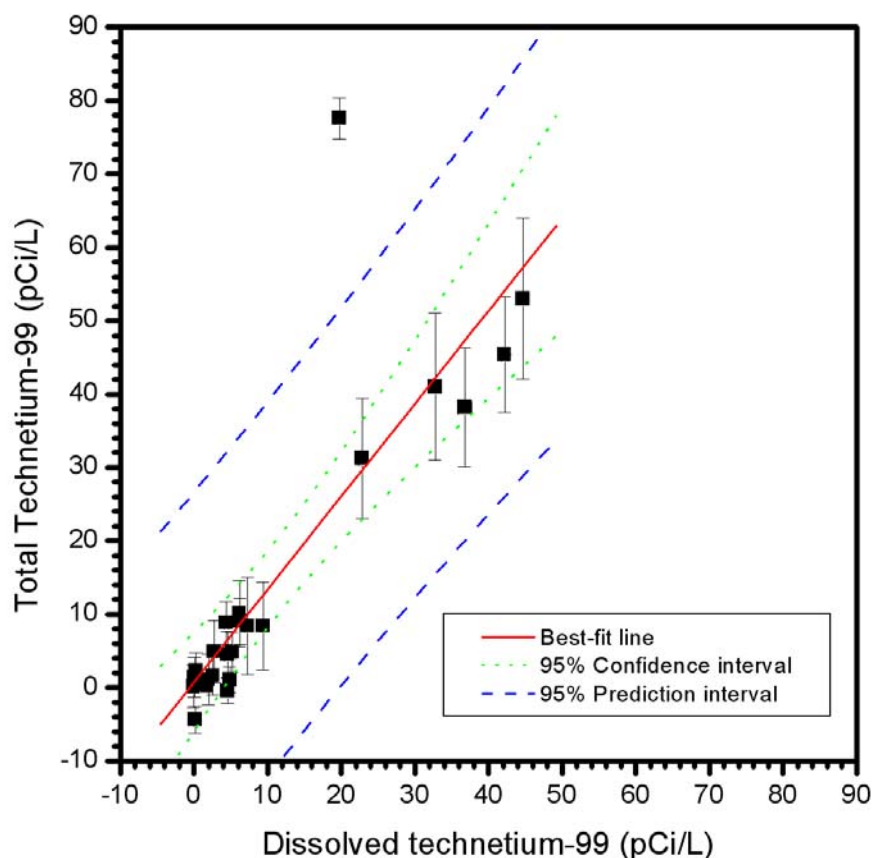


Figure 5-4c Comparison of dissolved and total technetium-99 analysis results, 2000-2002

Conclusions from this study indicate that the ion-selective method for analysis of technetium-99 developed by ISU-EML in 1999-2000, and improved on from that time through 2002 is a reasonable alternative to the radiochemistry method offered by subcontract labs. The benefits include increased sensitivity (about 1-2 pCi/L versus 3 - 9 pCi/L), and faster analysis time, as ISU-EML can conduct these analyses at its convenience. From 2003 on, the preferred analysis method by ISU-EML is ion-selective filter analysis.

Interprogram Comparisons of Water Results

The INEEL OP collects samples concurrently with the USGS and ESER. Goals for the water sampling conducted by these three organizations differ, but the use of similar analytical techniques serves to support meaningful interprogram data comparison.

Comparisons of available 2002 monitoring results were made for various radiological parameters for all co-sampled locations. Nonradiological results were compared for locations co-sampled with the USGS on and near the INEEL. A summary of the sampling locations, frequency, analyses, and methods specific to interprogram comparisons appears in **Chapter 2**.

During 2002, replicate co-samples were collected with the USGS at 24 groundwater and surface water locations on and near the INEEL. Two sites on the Big Lost River were not sampled due to lack of flow in the river. In addition, the INEEL OP and the USGS collected replicate groundwater and surface water samples at 18 locations (including one duplicate location) in the Magic Valley. Seven sites were also co-sampled with ESER, including two public drinking water wells along the INEEL boundary, and three springs and two drinking water supply wells south of the INEEL and in the Magic Valley.

Statistical comparisons were made for nonradiological analyses where the analyte of interest was present in both results of a data pair. Other criteria were used where a “less than” was reported for one or both samples. For radiological data, all analyses were used for statistical comparisons.

Linear regression analyses were applied to data where a sufficient number of replicate sample pairs were available. When such regressions were not meaningful, differences between replicate results were compared using histograms of the differences and evaluated with paired t-tests to compare population means. Relative percent differences are used for comparison when data are too limited (not enough data pairs) for comparison by other means. The linear regression is used because it can provide both an estimate of the mean difference between the INEEL OP result and co-sampling agency result, quantified by the y-intercept, and an estimate of the mean of y for a given x (shown by the slope of the regression). Hypothesis testing is used to determine if the y-intercept and slope terms are significant, as evidenced by associated t-statistics and probability values. Also displayed on the regression graphs are the 95 percent confidence interval about the regression line, and a 95 percent confidence interval for the predicted y value for a given x. If the more powerful regression is not statistically significant and meaningful, then a paired t-test is computed to determine if there is a significant difference between the paired data. Where censored data are presented (results reported simply as “<”) relative percent differences and comparisons relative to the reporting level are made.

Linear regressions were determined meaningful where a combination of factors applied: y-intercept and slope coefficients appeared reasonable (a positive slope approaching 1), the correlation coefficient (R) is sufficiently large (generally >0.80), and associated probability values (P for intercept, P for slope) for the slope and intercept indicate that the values are statistically significant (based on t-test statistics for $\alpha = 0.05$, or 95 percent confidence). Also reviewed were regression assumptions that residuals (the difference between the data value and the value predicted by the regression) versus predicted values were randomly distributed and that

the residuals themselves were normally distributed, and that the standard deviation of the residuals was small compared to the magnitude of the data. These plots were assessed qualitatively and are not presented here. The regression parameters are presented for all data sets where there are a sufficient number of data pairs (more than 2). If the regression was not significant then t-test results, a summary of the mean differences (the mean of the difference between result pairs), and a histogram of these differences are presented.

Nonradiological Results Comparisons

Linear Regression Comparisons

Samples collected by INEEL OP for nonradiological analyses are analyzed by the Idaho Bureau of Labs (IBL) in Boise and replicate samples from the USGS for nonradiological parameters are analyzed at the National Water Quality Laboratory (NWQL).

Regression results were meaningful for replicate data for chloride, chromium, nitrate plus nitrite, sodium, and sulfate. As summarized in **Table 5-3**, and depicted in **Figures 5-5** through **5-9**, linear regression comparisons of INEEL OP and USGS results showed good agreement for replicate data. Such agreement was not found for total phosphorus.

Table 5-3. Regression parameters with 95% confidence intervals for the replicate samples collected by the USGS and the INEEL OP, 2002

| Analyte | y-intercept | P for intercept | Slope | P for slope | R | SD of the residual | Number of replicate sample sets |
|---------------------------------|---------------|-----------------|-------------|-------------------|--------|--------------------|---------------------------------|
| Chloride | -0.72 ± 0.44 | 0.110 | 1.02 ± 0.01 | <10 ⁻⁴ | 0.998 | 2.10 | 42 |
| Chromium | -1.32 ± 3.59 | 0.724 | 0.95 ± 0.06 | <10 ⁻⁴ | 0.988 | 8.80 | 9 |
| Nitrate + nitrite (as nitrogen) | -0.03 ± 0.02 | 0.193 | 1.06 ± 0.02 | <10 ⁻⁴ | 0.997 | 0.06 | 25 |
| Total Phosphorus | 0.002 ± 0.002 | 0.548 | 0.71 ± 0.17 | 0.0004 | 0.671 | 0.003 | 23 |
| Sodium | -0.91 ± 0.25 | 0.009 | 1.03 ± 0.01 | <10 ⁻⁴ | 0.998 | 0.655 | 28 |
| Sulfate | 0.022 ± 0.61 | 0.973 | 1.01 ± 0.01 | <10 ⁻⁴ | 0.9996 | 1.52 | 13 |

Chloride

Forty-two replicate sample sets were collected for chloride in 2002. Regression analyses showed good agreement (**Figure 5-5**). The p-value for the y-intercept and slope indicate that the intercept term is not significant. The slope of the regression is very near 1.0 and the associated p-value is significant. The correlation coefficient (R) and the standard deviation indicated that the regression model reasonably predicts the relationship between USGS and INEEL OP chloride results. Because the USGS collects a filtered sample (dissolved chloride), while the INEEL OP collects an unfiltered sample (total chloride), this data agreement suggests that since there is no difference between the two, chloride present is largely in dissolved form.

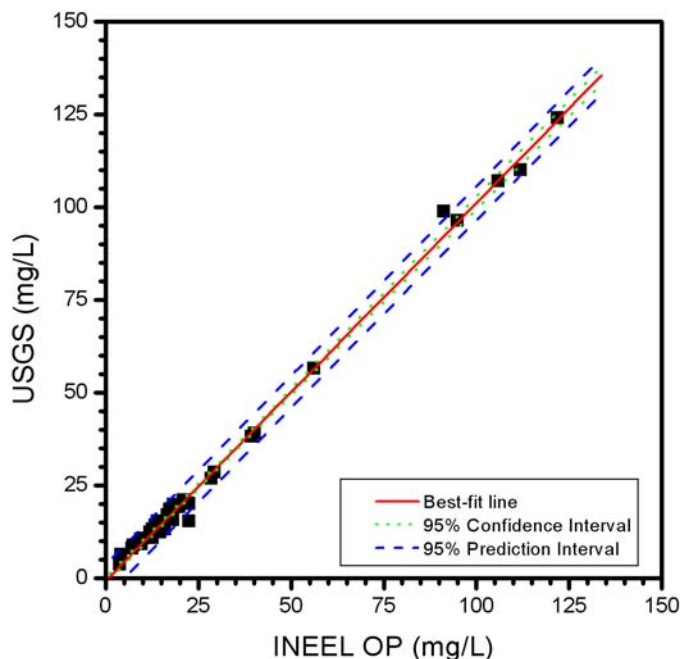


Figure 5-5. Concentrations of chloride reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2002

Chromium

Nineteen replicate dissolved chromium results were available for 2002. For these nineteen data pairs, eight INEEL OP results were less than the 5 µg/L MDC and nine USGS results were reported as less than the 10 µg/L MDC. For seven result pairs, both the USGS and INEEL OP results were reported as less than their respective MDCs. For another three pairs, one of the results was less than the reporting level. EPA guidance suggests that for replicate samples in which the concentrations are less than five times the MDC, results are comparable if they differ by less than the sample MDC (EPA, 1994). All of these replicates differed by less than the sample MDC.

Regression analyses, presented in **Figure 5-6**, showed very good agreement, with an intercept that does not differ from zero and a slope close to one. Chromium was detected in both results for nine replicate pairs. Although the number of data pairs is small, the regression is reasonably strong, as evidenced by the small uncertainty for the slope, the high correlation coefficient (R), and the relatively small standard deviation for the regression.

The nine replicate data pairs for chromium were also compared using a t-test, due to the small number of pairs without censored data (data reported as less than a reporting level). The conclusion from this test was that the mean of INEEL OP chromium results was not different than the co-located USGS results ($t = 1.13$ and $p = 0.2908$), confirming the conclusion from the linear regression that the INEEL OP and USGS results do not differ significantly.

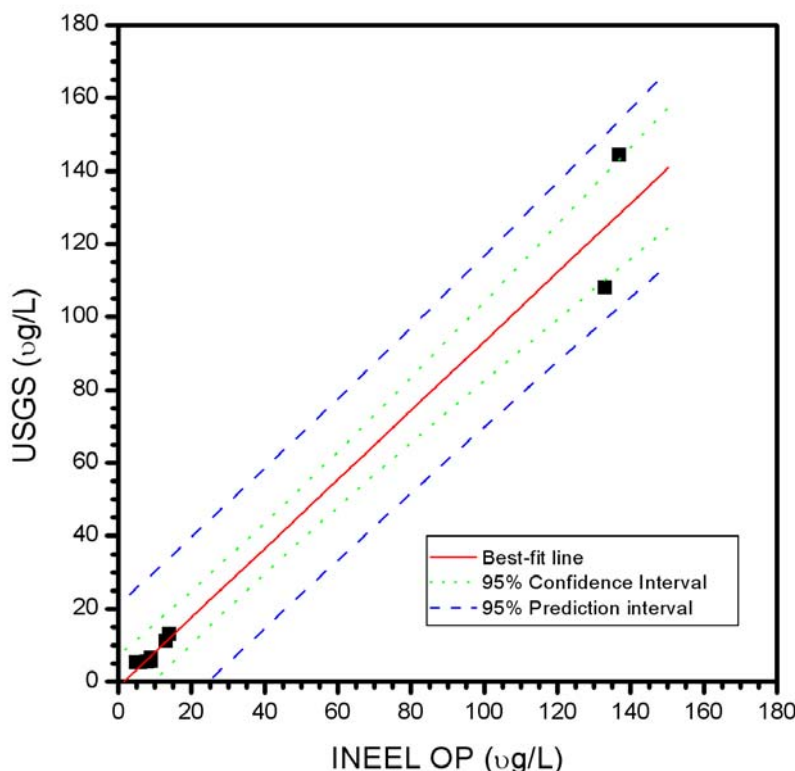


Figure 5-6. Concentrations of chromium reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2002

Nitrate plus Nitrite as Nitrogen and Total Phosphorus as P

Regression analysis for the 25 replicate values for nitrate plus nitrite for INEEL OP and USGS results (**Figure 5-7a**) also shows good agreement. The slope suggests a small difference between USGS and INEEL OP results (slope of 1.06 and uncertainty of 0.02). The p-value for the y-intercept indicates an intercept indistinguishable from zero.

Replicate analyses for total phosphorus as P were available for 26 sample pairs, with total phosphorus detected for both samples for 23 of these sample pairs. All results exceeded the 0.005 mg/L MDC detection level for the INEEL OP. Three results for USGS samples were less than the reporting level (0.01 – 0.02 mg/L) for their analyzing laboratory. Regression analysis of the 23 sample pairs where both had detections yielded a slope-value that was significant, but a correlation coefficient that was not. Because the regression was not considered significant, a paired t-test and histogram of differences was completed. The conclusion drawn from the t-test is that the mean of INEEL OP results differed from the mean of the USGS results ($t = 4.83$ and $p < 0.0001$). The mean for the differences between USGS and INEEL OP data pairs is 0.003 mg/L, less than the detection limit for either USGS or INEEL OP for this analyte. While an identifiable difference between USGS and INEEL OP total phosphorus results exists, the difference is small. A histogram of these differences is presented in **Figure 5-7a**.

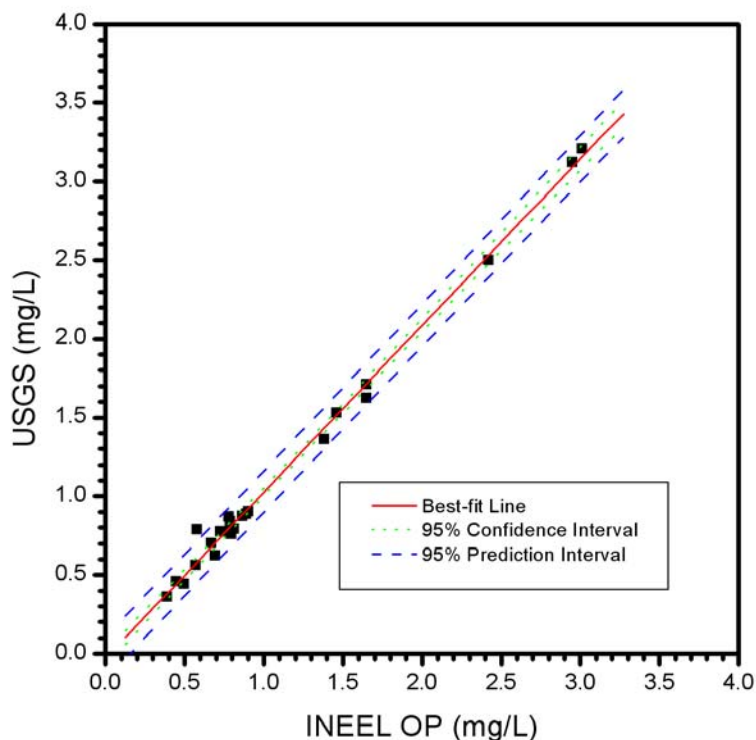


Figure 5-7a. Concentrations of dissolved nitrite plus nitrate as nitrogen reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2002

Sodium and Sulfate

There were 13 replicate results for sulfate and 28 replicate results for sodium. Sulfate results shown in **Figure 5-8** demonstrate good agreement, with a slope of 1.01 ± 0.01 and a y-intercept not differing from zero. The regression analyses presented in **Figure 5-9** indicate that the sodium results are well correlated with a slope of 1.03 ± 0.01 and a y-intercept slightly less than 0.

Relative Percent Differences Comparisons

Relative percent differences show excellent agreement for all of the analytes that could not be compared with linear regressions. **Table 5-4** demonstrates the comparison of the concentrations of these constituents reported in replicate samples during 2002.

Two replicate sample sets were collected for barium, lead, manganese, and zinc from USGS 65.

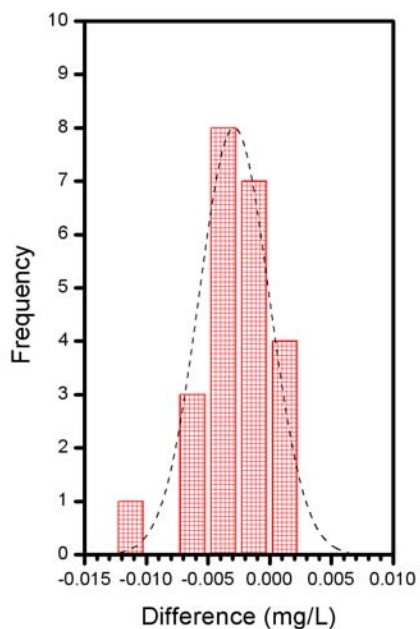


Figure 5.7b Histogram of differences for phosphorus analyses USGS and INEEL OP sampling, 2002.

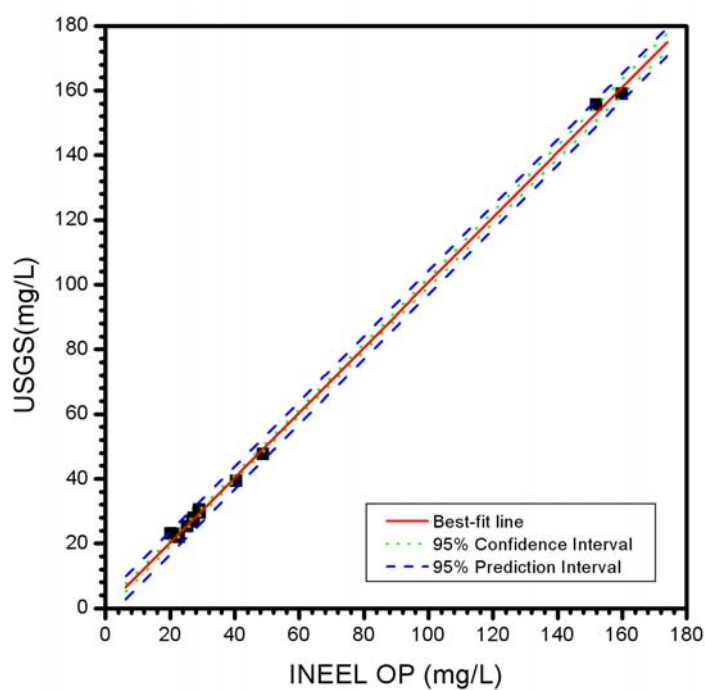


Figure 5-8. Concentrations of sulfate reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2002.

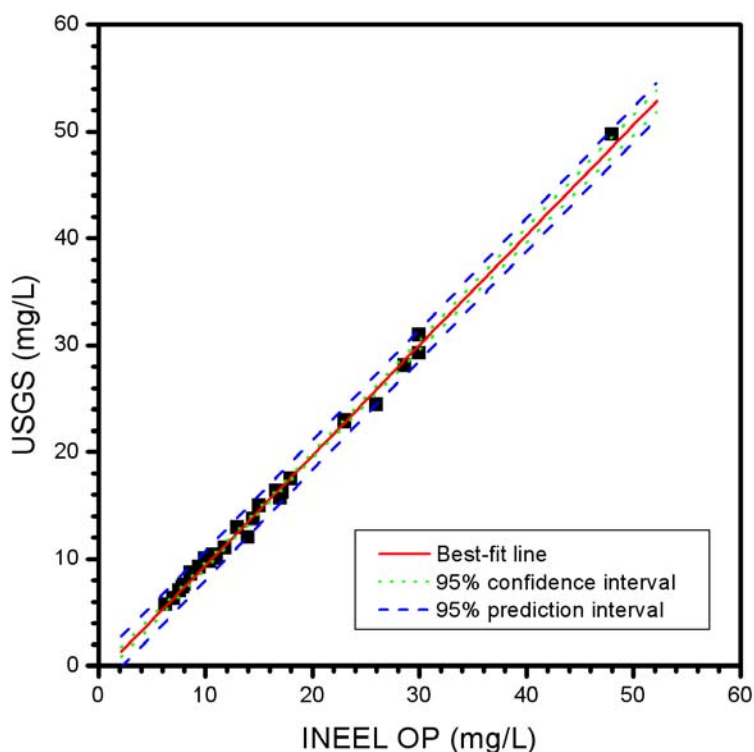


Figure 5-9. Concentrations of sodium reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2002.

Table 5-4. Comparison of common ion, nutrient, and trace metal concentrations reported for replicate samples, 2002

| Analyte | Number of replicate sample pairs | Number of pairs where analyte detected in both samples | Number of replicate pairs where relative percent difference <20%, or where results are within +/- detection limit | Percent of replicate samples with comparable results |
|----------------------------------|----------------------------------|--|---|--|
| Barium | 2 | 2 | 2 | 100 |
| Chromium | 19 | 9 | 10 ^a | 100 |
| Chloride | 42 | 42 | (compared by linear regression) | |
| Lead | 2 | 0 | 2 | 100 |
| Manganese | 2 | 0 | 2 | 100 |
| Sodium | 28 | 28 | (compared by linear regression) | |
| Sulfate | 13 | 13 | (compared by linear regression) | |
| Nitrite plus nitrate as nitrogen | 25 | 25 | (compared by linear regression) | |
| Phosphorus as P | 26 | 23 | 26 ^b | 100 |
| Zinc | 2 | 2 | 2 | 100 |

^a Fifteen replicate pairs compared by linear regression.
^b Linear regression was not meaningful.

In summary, comparisons of INEEL OP and USGS results for nonradiological analytes demonstrate very good agreement for all replicate data. Such close agreement in results indicates that data between respective programs are comparable, and that there are no significant biases introduced by differences in sample collection or analysis methods for replicate samples collected during 2002.

Radiological Results Comparisons

Results for gross alpha, gross beta, tritium, and strontium-90 were available for samples collected by the INEEL OP and the USGS on and near the INEEL, and for the USGS Magic Valley sampling program, an area including sites from the southern boundary of the INEEL to the Snake River between Twin Falls and Hagerman. Results are also available for the seven INEEL boundary and distant locations co-sampled by INEEL OP and ESER.

Differences in the sample collection and analysis methodology used by an individual agency can influence interprogram comparisons. **Table 5-5** provides a summary of collection and analysis methods used by the INEEL OP, ESER, and the USGS and their possible impacts on comparability of gross alpha and gross beta results.

For each analyte, regression analysis was attempted first. If the regression result was meaningful based on the criteria presented in the introduction to the previous section, Interprogram Comparisons, a plot of the data and regression was presented without discussion of further analysis. **Table 5-6** summarizes results of simple liner regression analyses for all datasets. The regressions that met the given criteria for being “meaningful” are identified.

When regression results were not meaningful, data were compared using a paired t-test to evaluate whether the means of the data were statistically different. **Table 5-7** summarizes these results. To characterize the differences between replicates, the result obtained by the INEEL OP was subtracted from ESER or USGS result. **Table 5-8** outlines these differences for each of the respective analytes.

Histograms of these differences were generated to identify outliers and illustrate how the differences are distributed with a normal curve fitted to the histogram. Where the INEEL OP collected field replicates, the mean of these replicates and the pooled analytical errors were compared to the replicate results from ESER and USGS.

Gross Alpha Radioactivity

A total of 51 replicate results for gross alpha radioactivity was available: 14 co-sampled with ESER, 19 with the USGS on and near the INEEL, and 18 with the USGS in the Magic Valley.

With regression results not meaningful, paired t-test analysis indicated that, at a 95 percent confidence level, the means of gross alpha radioactivity measurements made by the INEEL OP differed from those of ESER, and from the USGS in the Magic Valley, while results compared with the USGS on and around the INEEL were not statistically different. Comparison results are

presented in **Tables 5-6, 5-7, and 5-8**. Histograms of these differences are presented in **Figures 5-10, 5-11, and 5-12**.

INEEL OP gross alpha radioactivity results tended to be greater than that of ESER, and less than the USGS in the Magic Valley. Results compared with the USGS on and near the INEEL were comparable. Differences were small, less than the typical 2-s uncertainty for these measurements. Histograms of differences (**Figures 5-10, 11, and 12**) show that differences between the co-sample results appear to be normally distributed, thus indicating a random bias in the compared results. The differences between INEEL OP and ESER may be explained by the difference between instruments used. See **Table 5-5** for further discussion.

Table 5-5. Sampling and analysis techniques for gross alpha and gross beta samples collected by the INEEL OP, USGS and ESER, 2002

| Sampling or analytical technique | INEEL OP | ESER | USGS-INEEL Monitoring Program | USGS-Magic Valley Monitoring Program | Effect on measured concentration |
|---|---|--|---|---|--|
| Manufacturer, model, and operational mode for gas-proportional counting system, and typical count time. | Protean 5", automatic feed, thin-window, 300 minutes. | Canberra model 2404 1.85" (47 mm), automatic feed, thin-window, 125 minutes. | For alpha, scintillation counter and 60 minutes. For beta, Tennelec 2", automatic feed, thin-window (85 μ g/cm ²) 20 minutes. | Tennelec model 5100 automatic feed, thin-window, 125 minutes. | Differences in radiation detector models' operation and maintenance, and standard count-times can have significant impacts on counting efficiency and resulting MDC. In general terms, thicker windows, smaller detectors and shorter count times decrease sensitivity of the measurement. |
| Calibration isotope ^a gross alpha analyses | Thorium-230 | Thorium-230 | Plutonium-239 | Thorium-230 | In general, a lower energy standard would result in a slightly higher reported concentration. |
| Calibration isotope ^a gross beta analyses | Cesium-137 | Cesium-137 | Cesium-137 | Cesium-137 | In general, a lower energy standard would result in a slightly higher reported concentration. In the past, strontium-90 has been used as a calibration isotope for gross beta by some laboratories. |
| Filtration | Not Filtered | Not Filtered | Not Filtered | Filtered | Samples that are not filtered include dissolved and suspended constituents, which may result in a higher concentration than filtered samples containing only the dissolved fraction. |
| Preservation | Nitric acid added in the field | Nitric acid added in the field | Nitric acid added in the field | Nitric acid added in the field | Not preserving the sample in the field may result in radionuclides present in the sample adhering to the sample container, which could result in a lower measured concentration in the unpreserved sample. |

^a The lower the energy of the decay particle, the less efficient the detector. Because the concentration is determined by dividing the number of counts by the efficiency, calibration with a lower energy particle yields a higher concentration. Peak energies are listed below (from Shleien, 1992). (1) americium-241: 5.49 MeV alpha particle (85%) (2). Strontium-90/yttrium-90: 2.28 MeV beta particle (yttrium-90, 100%) (3) plutonium-239: 5.16 MeV alpha particle (73%) (4). 0.55 MeV beta particle (strontium-90, 100%) (5). thorium-230: 4.69 MeV alpha particle (76%) (6). cesium-137: 1.17 MeV beta particle (5%) and 0.51 MeV beta particle (95%).

Table 5-6. Summary of linear regression^a parameters with 95% confidence intervals for the replicate samples collected by INEEL OP, USGS, and ESER, 2002. Shaded row indicates a meaningful regression

| Analyte | Co-sampling Agency | y-intercept | P for intercept | Slope | P for slope | R | SD of the residual | Number of replicate sample sets |
|--------------|---------------------------|--------------|-------------------|--------------|-------------------|--------|--------------------|---------------------------------|
| Gross Alpha | ESER | 0.17 ± 0.28 | 0.569 | 0.05 ± 0.14 | 0.706 | 0.110 | 0.749 | 14 |
| | USGS (INEEL) ^a | 0.70 ± 0.17 | 0.0009 | 0.01 ± 0.12 | 0.903 | 0.030 | 0.534 | 19 |
| | USGS (MV) ^b | 3.54 ± 0.60 | <10 ⁻⁴ | -0.09 ± 0.25 | 0.733 | -0.087 | 1.83 | 18 |
| Gross Beta | ESER | -0.18 ± 2.59 | 0.945 | 1.74 ± 0.99 | 0.104 | 0.453 | 2.19 | 14 |
| | USGS (INEEL) ^a | 4.65 ± 0.79 | <10 ⁻⁴ | -0.24 ± 0.37 | 0.538 | -0.151 | 1.65 | 19 |
| | USGS (MV) ^b | 1.66 ± 1.21 | 0.189 | 1.72 ± 0.34 | 0.0001 | 0.786 | 1.87 | 18 |
| Cesium-137 | USGS (INEEL) ^a | 8.02 ± 6.31 | 0.218 | 0.18 ± 8.02 | 0.983 | 0.005 | 28.1 | 22 |
| Tritium | ESER | -67.7 ± 43.5 | 0.146 | 1.32 ± 1.00 | 0.214 | 0.354 | 162 | 14 |
| | USGS (INEEL) ^a | -24.5 ± 80.5 | 0.762 | 0.92 ± 0.02 | <10 ⁻⁴ | 0.991 | 450 | 41 |
| | USGS (MV) ^b | 23.1 ± 3.18 | <10 ⁻⁴ | 0.26 ± 0.10 | 0.011 | 0.584 | 13.4 | 18 |
| | USGS (MV) ^{bc} | -5.50 ± 3.00 | 0.084 | 1.16 ± 0.10 | <10 ⁻⁴ | 0.940 | 5.66 | 18 |
| Strontium-90 | USGS (INEEL) ^a | 1.14 ± 0.32 | 0.017 | 1.02 ± 0.04 | <10 ⁻⁴ | 0.996 | 0.673 | 7 |

^a USGS on and near the INEEL
^b USGS in the Magic Valley
^c Tritium results using electrolytic enhancement and liquid scintillation

Table 5-7. Summary of paired t-tests for replicate samples analyses, 2002. Shaded cells indicate means that differ at the 95% confidence level.

| Analyte | Co-sampling Agency | Mean of Data (pCi/L) | Standard Deviation of data | Number of Replicate Samples | t-statistic | Probability (P-Value) | Conclusion (at 95% Probability) |
|---|-------------------------------|----------------------|----------------------------|-----------------------------|-------------|-----------------------|---------------------------------------|
| Gross Alpha | | | | | | | |
| OP with ESER | | 1.41 0.24 | 1.46 0.72 | 14 | 2.813 | 0.0147 | Means are significantly different |
| OP with USGS (INEEL) ^a | | 1.05 0.72 | 1.06 0.52 | 19 | 1.24 | 0.2300 | Means are not significantly different |
| OP with USGS (MV) ^b | | 1.68 3.39 | 1.78 1.78 | 18 | -2.77 | 0.0130 | Means are significantly different |
| Gross Beta | | | | | | | |
| OP with ESER | | 2.56 4.27 | 0.61 2.36 | 14 | -2.97 | 0.0108 | Means are significantly different |
| OP with USGS (INEEL) ^a | | 1.87 4.21 | 1.04 1.62 | 19 | -4.98 | 0.0001 | Means are significantly different |
| OP with USGS (MV) ^b | Compared by linear regression | | | | | | |
| Cesium-137 | | | | | | | |
| OP with USGS (INEEL) ^a | | 0.24 8.07 | 0.77 27.4 | 22 | -1.33 | 0.1957 | Means are not significantly different |
| Tritium | | | | | | | |
| OP with ESER | | -2.86 -71.4 | 44.9 167 | 14 | 1.64 | 0.1256 | Means are not significantly different |
| OP with USGS (INEEL) ^a | Compared by linear regression | | | | | | |
| OP with USGS (MV) ^b | | 3.33 24.0 | 35.5 16.1 | 18 | -3.00 | 0.008 | Means are significantly different |
| Tritium ^c | | | | | | | |
| OP with USGS (MV) ^c | Compared by linear regression | | | | | | |
| Strontium-90 | | | | | | | |
| OP with USGS (INEEL) ^a | Compared by linear regression | | | | | | |
| ^a Locations on and near the INEEL ^b Distant, Magic Valley locations ^c Tritium analyzed using an electrolytic enhancement | | | | | | | |

Table 5-8. Summary of mean differences between results of replicate pairs, 2002

| Analyte | Co-sampling Agency | Mean difference (INEEL OP) (pCi/L) | Standard Deviation | Number of replicate pairs |
|--|---------------------------|------------------------------------|--------------------|---------------------------|
| Gross alpha | | | | |
| | ESER | -1.17 | 1.56 | 14 |
| | USGS (INEEL) ^a | -0.33 | 1.16 | 19 |
| | USGS (MV) ^b | 1.72 | 2.62 | 18 |
| Gross beta | | | | |
| | ESER | 1.71 | 2.15 | 14 |
| | USGS (INEEL) ^a | 2.35 | 2.05 | 19 |
| | USGS (MV) ^b | Compared by linear regression | | |
| Cesium-137 | | | | |
| | USGS (INEEL) ^a | 7.82 | 27.5 | 22 |
| Tritium | | | | |
| | ESER | -68.6 | 157 | 14 |
| | USGS (INEEL) ^a | Compared by linear regression | | |
| | USGS (MV) ^b | 20.7 | 29.2 | 18 |
| Tritium ^c | | | | |
| | USGS (MV) ^b | Compared by linear regression | | |
| Strontium-90 | | | | |
| | USGS (INEEL) ^a | Compared by linear regression | | |
| ^a Locations on and near the INEEL ^b Magic Valley sampling locations ^c Tritium measured using an Electrolytic Enhancement Method | | | | |

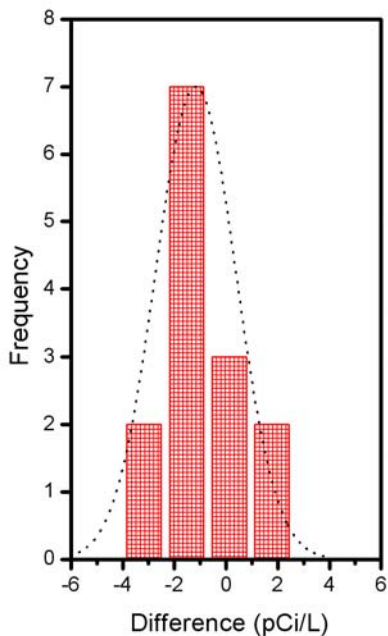


Figure 5-10. Histogram of differences between INEEL OP and ESER for gross alpha radioactivity, 2002.

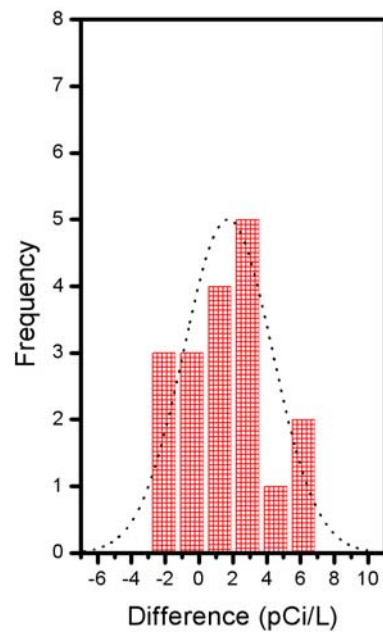


Figure 5-11. Histogram of differences between INEEL OP and USGS in the Magic Valley for gross alpha, 2002.

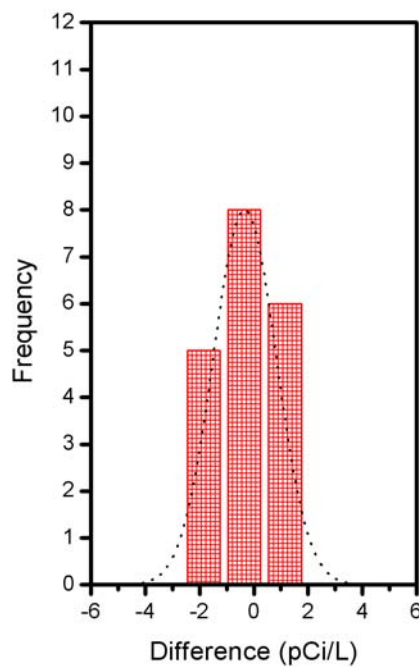


Figure 5-12. Histogram of differences between INEEL OP and USGS on and near the INEEL for gross alpha radioactivity, 2002.

Gross Beta Radioactivity

A total of 51 replicate results for gross beta radioactivity was available: 14 co-sampled with ESER, 19 with the USGS on and near the INEEL, and 18 with the USGS in the Magic Valley. Regression results were not meaningful for gross beta radioactivity compared with ESER and with USGS on and near the INEEL. Results for regression of INEEL OP and USGS in the Magic Valley **Figure 5-13** co-located samples suggest that the regression is meaningful, based on the p-value associated with the regression slope (0.0001, for slope of 1.72 ± 0.34), the correlation coefficient (R) (0.786), and review of residuals. The 2-sigma error bars included with figure 5-13 help to illustrate a difference in the level of precision between the INEEL OP and USGS results. Detection levels specific to the samples analyzed averaged 1.4 pCi/L for INEEL OP results and 3.4 pCi/L for USGS Magic Valley results. A meaningful regression has been obtained in three of the previous six years of comparisons, with regression slopes ranging from 1.18 to 1.63.

Paired t-test analyses were completed for INEEL OP and ESER, and INEEL OP and USGS on and near the INEEL (**Table 5-7**). The means of INEEL OP gross beta radioactivity measurements differed (at the 95-percent confidence level) from those of both USGS on and near the INEEL and ESER. Differences between replicate samples for gross beta radioactivity, presented in **Table 5-8**, showed that INEEL OP results for 2002 were less than those of ESER and the USGS on and near the INEEL. Mean differences were at or less than the typical 2-sigma sample counting uncertainty for ESER and just greater than the typical sample-specific MDC for USGS on and near the INEEL. This difference is consistent with comparisons from previous years. Histograms of these differences, presented in **Figures 5-13, 5-14, and 5-15** suggest that differences appear to be distributed normally. Contributing factors for observed differences between USGS results and those of INEEL OP include detector size and count times.

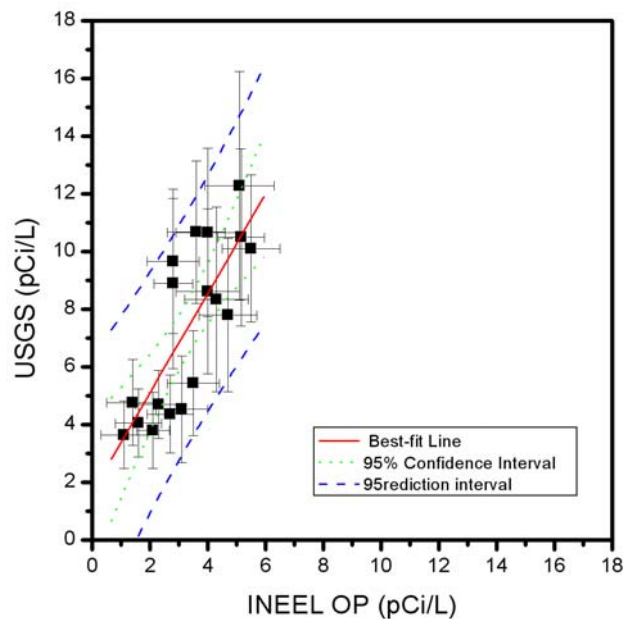


Figure 5-13 Comparison of replicate gross beta radioactivity results (with 2-sigma error bars) for INEEL OP and USGS in the Magic Valley, 2002.

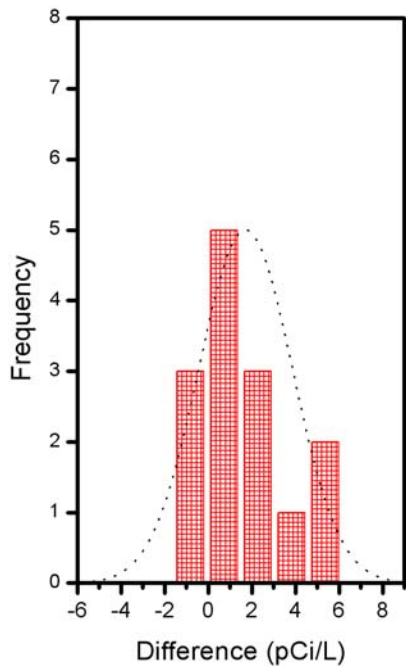


Figure 5-14. Histogram of differences between INEEL OP and ESER for gross beta radioactivity, 2002

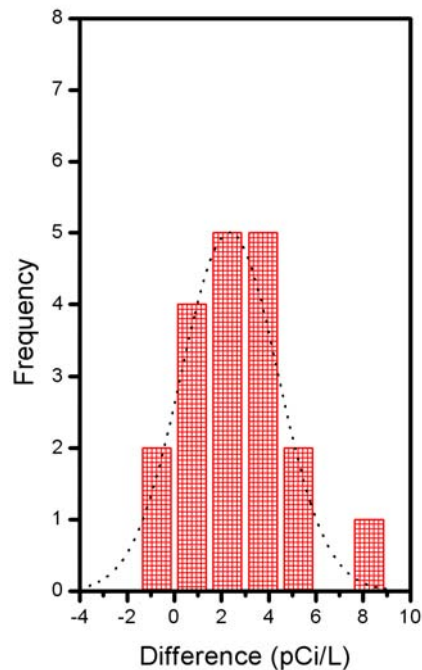


Figure 5-15. Histogram of differences between INEEL OP and USGS on and near the INEEL for gross beta radioactivity, 2002

Cesium-137

All of the 22 replicate results available for cesium-137 were for samples co-located with the USGS on the INEEL. Regression analysis was not meaningful, as noted on **Table 5-6**. Paired t-test analysis indicated that the means were not significantly different for cesium-137 analyses at a 95 percent confidence level. Mean differences, presented in **Table 5-8**, show that the USGS results on the INEEL were typically greater than the INEEL OP results, a difference likely due to the level of resolution (comparatively high MDC) of the USGS results (about 100 pCi/L) compared to about 2.5 pCi/L for INEEL OP results. The large differences in MDC are factors of the smaller volumes analyzed (400 ml of sample analyzed for USGS and 1,000 ml for INEEL OP) and the shorter counting times for those volumes (1 hour for USGS and 8 hours for INEEL OP). **Figure 5-16** presents the histogram of these results that shows differences that appear normally distributed.

Tritium

A total of 73 replicate results for tritium were available: 14 co-sampled with ESER, 41 with the USGS on and near the INEEL, and 18 with the USGS in the Magic Valley. As indicated in **Table 5-6**, regression results were not meaningful for locations co-sampled with the ESER and with the USGS in the Magic Valley, but were meaningful for locations co-sampled with the USGS on and near the INEEL.

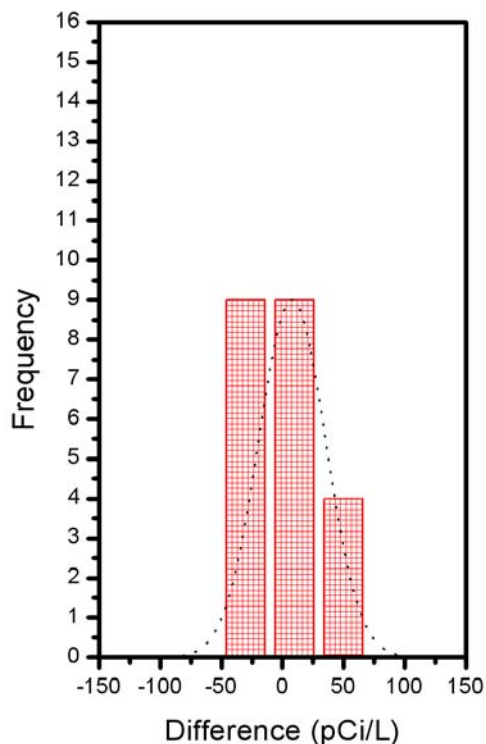


Figure 5-16. Histogram of differences between INEEL OP and USGS cesium-137 concentrations on and near the INEEL, 2002.

The regression results for sites co-sampled with the USGS on and near the INEEL (**Figure 5-17**) demonstrate good agreement. The regression slope for 2002 comparisons (0.92 ± 0.02), combined with all supporting information, indicates good agreement between INEEL OP and USGS tritium on and near the INEEL.

Replicate tritium results for ESER and INEEL OP, compared by paired t-test, did not differ, while INEEL OP compared with USGS in the Magic Valley, differed at the 95 percent confidence level. Histograms of these differences are presented in **Figures 5-18** and **5-19**, show differences normally distributed.

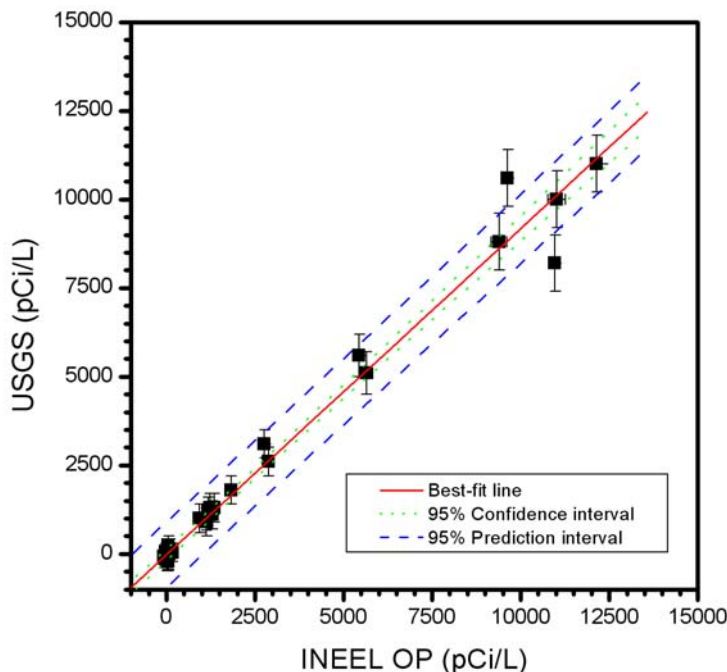


Figure 5-17. Comparison of replicate tritium results (with 2-s error bars) for INEEL OP and USGS for sites on and near the INEEL, 2002.

Enhanced Tritium

The USGS National Water Quality Laboratory uses an enrichment and liquid scintillation method with increased counting times to measure tritium at very low levels. This method provides an MDC of approximately 3 pCi/L, about 100 times lower than liquid scintillation alone reported by the USGS on and near the INEEL, suitable for measuring tritium at background levels. ISU EML uses a similar electrolytic enrichment method for tritium analyses, lowering sample MDCs to less than 25 pCi/L (practice has shown MDC values from 10-15 pCi/L), within the range typically observed for background levels of tritium for the Eastern Snake River Plain Aquifer (0 to 40 pCi/L).

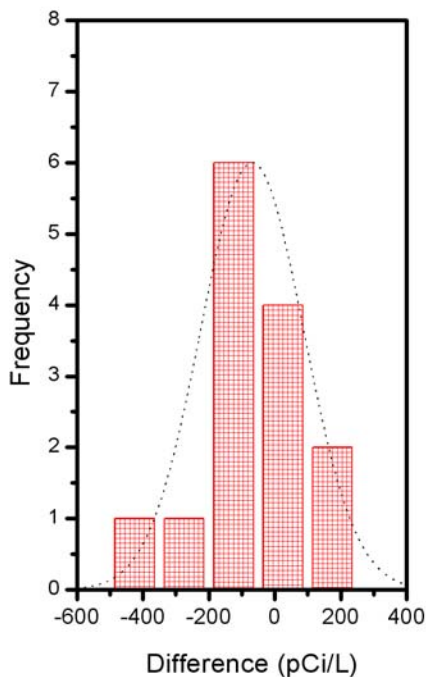


Figure 5-18. Histogram of differences between INEEL OP and ESER for Tritium, 2002.

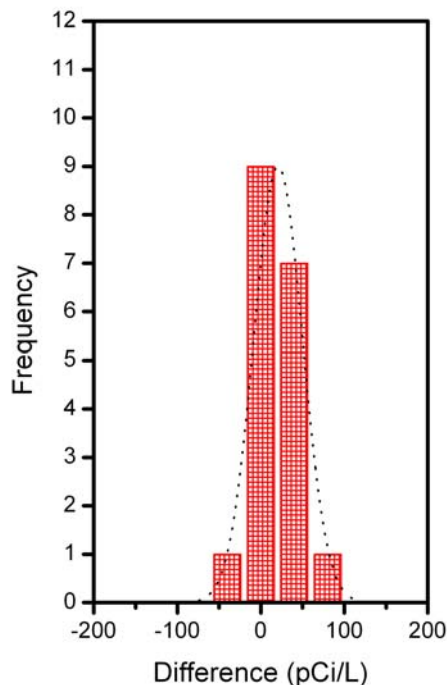


Figure 5-19. Histogram of differences between INEEL OP and USGS Magic Valley for Tritium by the standard method, 2002

Eighteen replicate samples were collected with the USGS in the Magic Valley for environmental-level tritium analysis. Results were compared with tritium analyses from the USGS National Water Quality Laboratory (**Figure 5-20**). The regression for low-level tritium results from ISU-EML and the USGS were comparable, with a slope of 1.16 ± 0.11 , and a y-intercept indistinguishable from zero. Two of the 18 replicate data pairs for enhanced tritium differed by more than 3-times the pooled sample uncertainty. For both of these result pairs, INEEL OP enhanced tritium results were higher than those for USGS. As seen from the y-intercept of the regression analysis, the mean of INEEL OP enhanced tritium results did not differ from the mean of the USGS Magic Valley tritium measurements.

Strontium-90

Seven replicate results for strontium-90 for four locations co-sampled with the USGS on the INEEL were compared. Regression analysis of these data, shown on **Figure 5-21**, correlates reasonably well for such a small number of compared samples. The regression slope was 1.02 ± 0.04 , suggesting very good agreement between USGS results completed by the Department of Energy Radiological and Environmental Sciences Laboratory (DOE-RESL), and INEEL OP results for strontium-90, completed by Paragon Analytics, Inc. While the y-intercept for this regression was statistically significant, the value was less than the typical 2-sigma uncertainty of the USGS results compared.

Summary of Differences

While statistically significant differences (at the 95 percent confidence level) were observed for gross alpha and gross beta, and for one group of tritium replicate results, these differences were relatively small compared to the concentrations observed. **Figure 5-22** summarizes the relative differences between INEEL OP results and replicate results from ESER and USGS on and near the INEEL and in the Magic Valley.

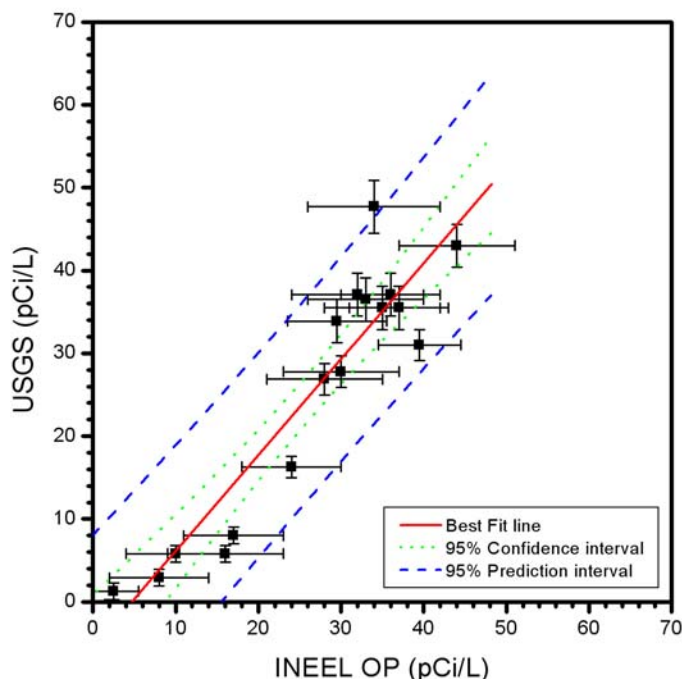


Figure 5-20. Comparison of replicate results for tritium by electrolytic enrichment and liquid scintillation (with 2-sigma error bars) for the USGS MV and INEEL OP, in the Magic Valley, 2002.

The x-axis (**Figure 5-22**) shows the mean and standard deviation of differences for individual replicate results divided by the absolute value of the INEEL OP result for that data pair. Dividing by the INEEL OP result serves to normalize the differences, with the unitless computation result being a “relative mean difference.”

The mean relative differences for all data sets are within one standard deviation of the zero difference line. The range of relative differences is less than about 20 with the exception of cesium-137 with the USGS on and near the INEEL. The difference between INEEL OP and USGS MDC analysis methods (volumes analyzed and sample counting times, as previously discussed) can explain the wide range of relative difference (-187 to 103 with a mean of -42). While their respective analysis methods may be sufficient for the goals of the USGS and the INEEL OP, such a difference makes meaningful comparison difficult. However, replicate results for both the USGS on the INEEL and INEEL OP conclude that cesium-137 is not detectable in replicate samples collected. Such results do provide an informative example of the impact that differences in analytical methods can have on a given set of data.

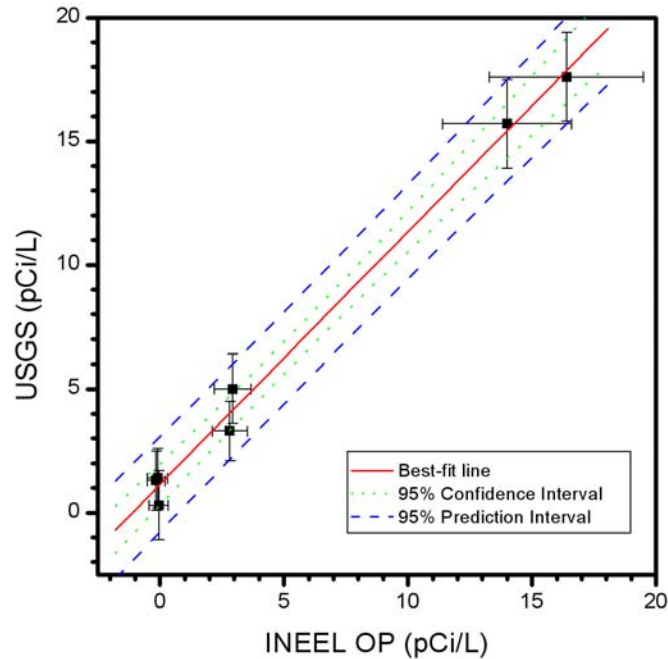


Figure 5-21. Comparison of replicate results for strontium-90 (with 2-sigma error bars), INEEL OP and USGS on and near the INEEL, 2002.

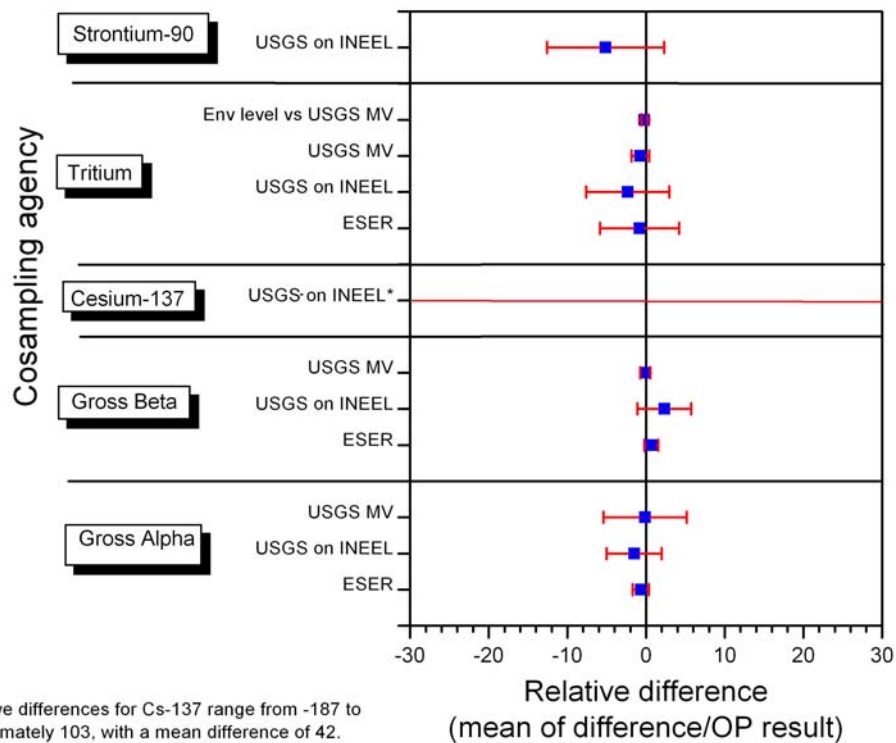


Figure 5-22. Summary of relative differences between INEEL OP results and replicate results from ESER and USGS on and near the INEEL and in the Magic Valley.

Comparison of replicate radiological results with ESER and with the USGS on and near the INEEL and in the Magic Valley did show some differences, the biases appeared relatively small (much less than any drinking water standard) and could be explained by differences in laboratory and sample collection methods. In general, comparison of results from these co-sampling organizations verified that, while the differences between replicate results obtained by these agencies and INEEL OP may have statistical significance (i.e., failing the statistical criteria), the magnitude of any differences is small compared to the magnitude of the data and the reporting levels.

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Chapter 6

Verification Water Monitoring Program

Major Findings and Development

In 2002, the INEEL OP collected replicate groundwater and wastewater samples at 33 sites with the DOE's primary contractor (BBWI), ANL-W, and NRF.

Results reported by the INEEL OP were comparable to those reported by BBWI, ANL-W, and NRF for most analytes. The observed differences were attributable to issues including laboratory analysis failure (fluoride), sample heterogeneity (primarily for wastewater samples), or the use of different analytical methods (gross radioactivity).

Introduction

The objective of the INEEL OP's verification program is to verify and supplement the analytical data reported for wastewater and groundwater samples collected by BBWI, ANL-W and NRF. Sampling is limited to long-term monitoring programs such as those developed for CERCLA Records of Decision (RODs), Wastewater Land Application Permits (WLAP), and environmental surveillance. The sampling program was not designed to duplicate DOE's extensive sampling network, but rather to collect a sufficient number of samples, typically about 10 percent to provide an additional level of confidence in the analytical data reported by DOE. During 2002, the INEEL OP collected replicate samples at 22 groundwater and 11 wastewater locations shown in **Figure 2-7** in **Chapter 2**. The analytical results are summarized in **Table 6-1**.

Because the samples are collected for various purposes (WLAP, CERCLA, surveillance), the analytes and analytical methods vary between programs. Therefore, the interprogram comparison is performed on a per sample basis; that is, each analytical result is compared directly to the result reported by the INEEL OP. As sites and analytical results available for comparison are likely to change from year to year as monitoring to meet regulatory and compliance needs change, trending of results may not be appropriate.

Table 6-1. Range of concentrations reported for INEEL OP samples collected with ANL-W, BBWI, and NRF, 2002

| Analyte | Range of Concentrations | | | | Drinking Water Standard ^a |
|--------------------------|-------------------------|---------|-------------|---------|--------------------------------------|
| | Wastewater | | Groundwater | | |
| | Minimum | Maximum | Minimum | Maximum | |
| Common Ions (mg/L) | | | | | |
| Alkalinity (as CaCO3) | 96 | 549 | 96 | 204 | None |
| Calcium | 6.9 | 1521 | 26.6 | 125 | None |
| Chloride | 12.4 | 17000 | 12.1 | 288 | SMCL=250 |
| Fluoride ^f | 0.28 | 1.6 | 0.3 | 0.74 | SMCL=2, MCL = 4 |
| Magnesium | 2.3 | 464 | 11.3 | 31.9 | None |
| Potassium | 2.8 | 73 | 2.4 | 5.3 | None |
| Silica | 11.5 | 46.4 | 19.2 | 33.9 | None |
| Sodium | 11 | 8250 | 8.1 | 112 | None |
| Sulfate | <2 | 91.6 | 17.6 | 126 | SMCL=250 |
| Total Dissolved Solids | 228 | 28208 | 176 | 990 | SMCL=500 |
| Total Suspended Solids | <1 | 196 | <1 | 20 | None |
| Nutrients (mg/L) | | | | | |
| Ammonia (as N) | 1.07 | 1.04 | <0.005 | <0.005 | None |
| Nitrite (as N) | <0.005 | <0.005 | <0.005 | 0.009 | 1 |
| Nitrite + Nitrate (as N) | 0.011 | 3.39 | 0.826 | 4.58 | 10 |
| Phosphate (as P) | 0.196 | 6.94 | 0.008 | 0.087 | None |
| Total Kjeldahl N (TKN) | 0.11 | 40.3 | <0.05 | 0.25 | None |
| Trace Metals (µg/L) | | | | | |
| Aluminum | <100 | 1400 | <50 | 580 | SMCL=50-200 |
| Antimony | <5 | 8 | <5 | <5 | 6 |
| Arsenic | 6 | 8 | <5 | <5 | 10 |
| Barium | 12 | 2850 | 21 | 198 | 2000 |
| Beryllium | <1 | <1 | <1 | <1 | 4 |
| Cadmium | <1 | 2 | <1 | <1 | 5 |
| Chromium | <5 | 33 | <5 | 161 | 100 |
| Cobalt | <5 | <100 | <5 | <10 | None |
| Copper | <10 | 140 | <10 | 10 | SMCL=1000, AL = 1300 |
| Iron | 30 | 4530 | 10 | 1600 | SMCL=300 |
| Lead | <5 | 36 | <5 | <5 | AL=15 |
| Manganese | <2 | 300 | <1 | 12 | SMCL=50 |
| Mercury | <0.5 | <0.5 | <0.5 | <0.5 | 2 |
| Nickel | <10 | 12 | <10 | <10 | None |
| Selenium | <10 | <50 | <10 | <10 | 50 |

Table 6-1 continued. Range of concentrations reported for INEEL OP samples collected with ANL-W, BBWI, and NRF, 2002

| Analyte | Range of Concentrations | | | | Drinking Water Standard ^a |
|--|-------------------------|-----------|-------------|-----------|--------------------------------------|
| | Wastewater | | Groundwater | | |
| | Minimum | Maximum | Minimum | Maximum | |
| Silver | <1 | 100 | <1 | <1 | SMCL = 100 |
| Thallium | <1.5 | <7.5 | <1.5 | <1.5 | 2 |
| Vanadium | <100 | <100 | <100 | <100 | None |
| Zinc | 7 | 248 | <5 | 254 | SMCL=5000 |
| Volatile Organic Compounds (µg/L) ^b | | | | | |
| Carbon Tetrachloride | NR ^c | NR | <0.39 | 1.18 | 5 |
| Radionuclides (pCi/L) ^d | | | | | |
| Americium-241 | NR | NR | <MDC | <MDC | 15 |
| Cesium-137 | <MDC | <MDC | <MDC | <MDC | 200 |
| Cobalt-60 | <MDC | <MDC | <MDC | <MDC | 100 |
| Gross Alpha (as Am-241) | <MDC | 3.6±1.2 | <MDC | 42.5±3.5 | 15 |
| Gross Beta (as Cs-137) | <MDC | 11.7±1.2 | <MDC | 21.0±1.6 | 200 ^e |
| Neptunium-237 | NR | NR | <MDC | <MDC | 15 |
| Strontium-90 | <MDC | 0.54±0.24 | <MDC | 2.82±0.58 | 8 |
| Plutonium-238 | NR | NR | <MDC | <MDC | 15 |
| Plutonium-239/240 | NR | NR | <MDC | <MDC | 15 |
| Plutonium-241 | NR | NR | <MDC | <MDC | 15 |
| Technetium-99 | NR | NR | <MDC | 1.2±0.5 | 900 ^e |
| Tritium | <MDC | 170±90 | <MDC | 15520±270 | 20000 |
| Uranium-234 | NR | NR | 7.5±1.0 | 7.5±1.0 | 20 µg/L |
| Uranium-235 | NR | NR | 0.45±0.15 | 0.45±0.15 | 20 µg/L |
| Uranium-236 | NR | NR | 8.1±1.1 | 8.1±1.1 | 20 µg/L |
| ^a Maximum contaminant level (MCL) unless otherwise noted. AL=Action Level from Lead and Copper Rule; SMCL=Secondary maximum contaminant level. | | | | | |
| ^b List limited to analytes detected in at least one sample. See Table 6-3 for a complete list of analytes. | | | | | |
| ^c NR=Not requested | | | | | |
| ^d Counting uncertainty reported at 2 sigma. | | | | | |
| ^e For beta-emitters, the maximum contaminant level is expressed as a cumulative annual dose of 4 millirem/year; for cesium-137, this is equivalent to 200 pCi/L, if cesium-137 were the only radionuclide detected. | | | | | |
| ^f Quality assurance problems at IBL resulted in rejection of 23 of 47 fluoride results. | | | | | |

Comparison of Nonradiological Results

For non-radionuclide analyses, if the reported concentration of the analyte exceeded the detection limit by a factor of five or more in both samples, the relative percent difference (RPD) between the two analytical results was calculated using the following equation:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

where:

C₁ = reported concentration of the analyte in the sample collected by the INEEL OP

C₂ = reported concentration of the analyte in the sample collected by the contractor

An RPD of ≤30 percent is considered acceptable for inorganics, and an RPD of ≤40 percent is acceptable for organic compounds. For replicate samples in which one, or both, of the results reported for a particular analyte are less than five times the detection limit, the results are considered comparable if the two results differ by an amount equal to or less than twice the detection limit. These comparison criteria are based primarily on the degree of accuracy the IBL and the EPA requires for internal matrix spikes (EPA, 1994; 1994a). The INEEL OP has adopted these standards as guidelines. If less than 90 percent of the replicates for a particular analyte meet the desired level of accuracy, the results are investigated further. For 2002, eleven inorganic analytes failed to meet these criteria and required additional evaluation (**Table 6-2**).

Most INEEL OP fluoride analyses (23 of 35) were rejected due to laboratory issues, leaving no data pairs available for comparison. Corrective actions taken by IBL during 2003 appear to have remedied this situation (Frederick, 2003).

Replicate sample pairs for total kjeldahl nitrogen (TKN), total phosphorus, total suspended solids, sulfate, copper, and aluminum that failed comparison criteria were all unfiltered wastewater samples. Heterogeneity of wastewaters can often explain such differences, which can be compounded for unfiltered samples. Replicate pairs for total nitrite plus nitrate failing the comparison criteria were all unfiltered samples (two ground water and two wastewater).

Replicate pairs for iron and zinc that failed the comparison criteria were unfiltered ground water samples. Differences in the amount of suspended particulate iron (e.g., rust and basalt fragments) in the replicate samples can result in significant differences in the reported iron concentration. Such differences may also account for variation in zinc concentrations.

Only comparisons for trichloroethene failed to meet the criteria of ≥90 percent comparable results for volatile organic compounds (VOCs). Trichloroethene was detected in at least one sample in each of eleven sample pairs, with seven meeting the comparison criteria (**Table 6-3**). Three of the failing samples pairs were qualified as estimates.

Table 6-2. Comparison of concentrations of common ions, nutrients, and trace metals reported for replicate samples collected with ANL-W, BBWI, and NRF, 2002

| Analyte | Number of replicate sample pairs | Number of pairs where analyte detected in both samples | Number of replicate pairs where relative percent difference \leq 30%, or where results are within twice the detection limit | Percent of replicate samples with comparable results |
|------------------------------------|----------------------------------|--|---|--|
| Common Ions | | | | |
| Alkalinity (as CaCO ₃) | 3 | 3 | 3 | 100 |
| Calcium | 20 | 20 | 19 | 95 |
| Chloride | 22 | 22 | 22 | 100 |
| Fluoride | 8 | 7 | 0 ^a | 0 |
| Magnesium | 20 | 20 | 19 | 95 |
| Potassium | 20 | 20 | 19 | 95 |
| Sodium | 27 | 27 | 27 | 100 |
| Sulfate | 16 | 15 | 14 | 88 |
| Total Dissolved Solids | 13 | 13 | 11 | 85 |
| Total Suspended Solids | 9 | 9 | 2 | 33 |
| Nutrients | | | | |
| Ammonia (as N) | 3 | 0 | 3 | 100 |
| Nitrite (as N) | 7 | 1 | 7 | 100 |
| Nitrite+Nitrate (as N) | 26 | 24 | 22 | 85 |
| Total Phosphorus (as P) | 18 | 14 | 15 | 83 |
| Total Kjeldahl N (TKN) | 18 | 12 | 13 | 72 |
| Trace Metals | | | | |
| Aluminum | 26 | 6 | 23 | 89 |
| Antimony | 24 | 1 | 24 | 100 |
| Arsenic | 27 | 27 | 27 | 100 |
| Barium | 28 | 28 | 27 | 96 |
| Beryllium | 24 | 0 | 24 | 100 |
| Cadmium | 26 | 0 | 26 | 100 |
| Chromium | 30 | 21 | 30 | 100 |
| Cobalt | 16 | 0 | 16 | 100 |
| Copper | 26 | 4 | 23 | 86 |
| Iron | 28 | 19 | 21 | 75 |
| Lead | 29 | 1 | 29 | 100 |
| Manganese | 28 | 18 | 28 | 100 |
| Mercury | 30 | 0 | 30 | 100 |
| Nickel | 25 | 1 | 25 | 100 |
| Selenium | 30 | 0 | 30 | 100 |
| Silver | 28 | 1 | 28 | 100 |
| Thallium | 28 | 0 | 26 | 93 |
| Vanadium | 15 | 0 | 15 | 100 |
| Zinc | 26 | 18 | 22 | 85 |

^a INEEL OP fluoride analyses were rejected due to laboratory quality assurance problems.

Table 6-3. Comparison of concentrations of volatile organic compounds reported for replicate samples collected with BBWI and NRF, 2002

| Analyte | Number of replicate sample pairs | Number of pairs where analyte detected in one or both samples | Number of replicate pairs where relative percent difference \leq 40%, or where results are within twice the detection limit | Percent of replicate samples with comparable results |
|--------------------------|----------------------------------|---|---|--|
| Carbon tetrachloride | 23 | 4 | 22 | 96 |
| Chloromethane | 23 | 1 | 23 ^a | 100 |
| cis-1,2-Dichloroethene | 23 | 4 | 22 | 96 |
| trans-1,2-Dichloroethene | 23 | 4 | 22 | 96 |
| Methylene chloride | 23 | 5 | 22 ^b | 96 |
| Tetrachloroethene | 23 | 6 | 23 | 100 |
| Trichloroethene | 23 | 11 | 19 | 87 |

^a Chloromethane, detected in two samples collected by the contractor, was also detected in associated blank samples. The two contractor results were qualified as "JBU".

^b Methylene chloride was detected in five contractor samples. For three of those samples, methylene chloride was also detected in associated blank samples and were qualified as such. One sample pair was within comparison criteria (+/- two-times the detection limit). One pair not qualified with "B" returned results failing the comparison criteria.

Comparison of Radiological Analyses

Unlike the nonradioactive constituents for which analytical error is not reported, the analytical (counting) error must be considered when evaluating radioactivity analyses. Therefore, the results reported for the replicate radionuclide analyses are considered to be comparable if either:

$$1) \quad |C_1 - C_2| \leq 3(s_1^2 + s_2^2)^{1/2}$$

where:

C_1 = reported concentration of the analyte in the sample collected by the INEEL OP

C_2 = reported concentration of the analyte in the sample collected by the contractor

s_1 = sample standard deviation of the INEEL OP sample

s_2 = sample standard deviation of the contractor sample

or

2) The relative percent difference (RPD) was less than or equal to 20 percent.

The approach outlined above is used by the ISU EML to determine whether the results of its duplicate analyses are within control limits.

As shown in **Table 6-4**, radiological analyses for gross alpha, gross beta, and technetium-99 failed the comparison criteria.

Differences between gross alpha and gross beta concentrations can be related to differences in the size and type of detectors, window density thickness, calibration isotopes, and calibration assumptions used. While these differences were observed, no consistent bias was observed.

While two of six analyses for technetium-99 failed the comparison criteria, technetium-99 was not detected in any of the sample pairs.

Table 6-4. Comparison of radionuclide concentrations reported for replicate samples collected with ANL-W, BBWI, and NRF, 2002

| Analyte | Number of replicate sample pairs | Number of pairs where analyte detected in both samples | Number of replicate pairs where relative percent difference \leq 20%, or where results are within three times the weighted counting error | Percent of replicate samples with comparable results |
|-------------------------|----------------------------------|--|---|--|
| Americium-241 | 9 | 0 | 9 | 100 |
| Cesium-137 | 18 | 0 | 18 | 100 |
| Gross Alpha (as Am-241) | 14 | 1 | 12 | 86 |
| Gross Beta (as Cs-137) | 14 | 10 | 6 | 43 |
| Plutonium-238 | 8 | 0 | 8 | 100 |
| Plutonium-239/240 | 8 | 0 | 8 | 100 |
| Strontium-90 | 12 | 2 | 12 | 100 |
| Technetium-99 | 6 | 1 | 4 | 67 |
| Tritium | 23 | 10 | 22 | 96 |

References

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Chapter 7

External Radiation Monitoring

Major Findings and Developments

Ambient penetrating exposure measurements performed during 2002 were consistent with historical background measurements. Redundancy in data collection and use of passive radiation detectors provided adequate cumulative average exposure rates at each gamma monitoring location.

- No offsite environmental impacts from INEEL operations were detected with environmental ambient gamma radiation exposure-rate measurements.
- Interprogram comparisons of different surveillance program results show good agreement. Discrepancies are attributable to differences in monitoring schedules and different penetrating radiation measurement techniques.

Ambient Penetrating Radiation Monitoring and Trends

Radiological conditions are monitored by INEEL OP through the use of measurement devices that are capable of measuring ambient, penetrating radiation exposures at locations on the INEEL, near the INEEL boundary, and at distant locations with respect to INEEL. INEEL OP uses a network of 12 high-pressure ion chambers (HPICs) to monitor exposure rates “real time.” Eleven of the HPIC stations are owned and operated by INEEL OP and one station is owned and operated by the Shoshone-Bannock tribes at Fort Hall. Data collected at Fort Hall are transmitted to the INEEL OP office via the same radio telemetry network used to collect data from the stations owned and operated by INEEL OP.

INEEL OP uses electret ion chambers (EICs) to supplement data collected using the HPIC network and to provide additional information regarding environmental conditions on the INEEL during emergency or upset conditions. EICs are deployed as environmental dosimeters to measure cumulative exposure at 91 monitoring locations on the INEEL, near the INEEL boundary, and at distant locations. Of these 91 locations, there are 68 monitoring locations on

the INEEL along highways, access roads (along northwest and eastern INEEL boundaries), and at INEEL facilities (**Figure 7-1**). Of the 23 remaining locations, 11 are located at boundary locations and 12 at distant locations (**Figure 7-2**).

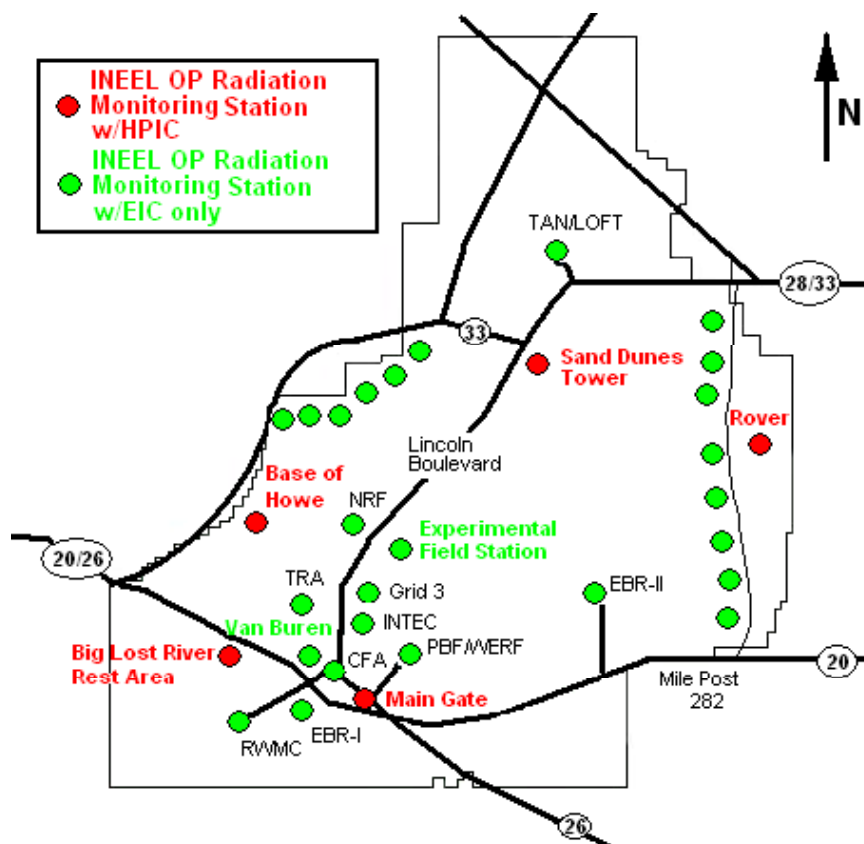


Figure 7-1. Penetrating radiation monitoring stations located on the INEEL maintained and operated by INEEL OP. Not included are the electret ion chambers located at mile markers along Highway 33, Highway 20/26, Highway 28/33, Highway 20, and Lincoln Boulevard.

Data collected using either the HPIC network or the EIC network are closely examined to identify potential trends or indicate potential upset conditions during INEEL operations. Ambient penetrating radiation is ubiquitous in the environment due to cosmic sources, naturally occurring radionuclides found in rock and soil, and man-made sources including historic above-ground testing of nuclear weapons and nuclear reactor operation.

Since the environment has measurable amounts of ambient penetrating radiation, INEEL OP has established an action level to set a threshold where additional scrutiny may be needed to identify significant changes in radiation levels. In the event that a measurement exceeds twice its expected “background” measurement, INEEL OP developed a set of procedures that will take place to identify the cause of the increase. Such increases may be due to improper instrument operations (which are remedied through quality control procedures as soon as they are identified), natural fluctuations in background (e.g., cosmic events, solar events, changes in meteorological conditions like sudden thundershowers or temperature inversions), or upset

conditions at INEEL. If the action level is exceeded for more than three sequential measurements, the direct cause will be investigated. The action levels for radiation monitoring have been arbitrarily established at twice the expected background exposure rate. The background exposure rate is estimated from expected cosmic ray exposure based upon HPIC measurements at various elevations¹ and gamma exposure rates² estimated from *in-situ* gamma spectroscopic measurements for gamma emitting radionuclides in local soils.

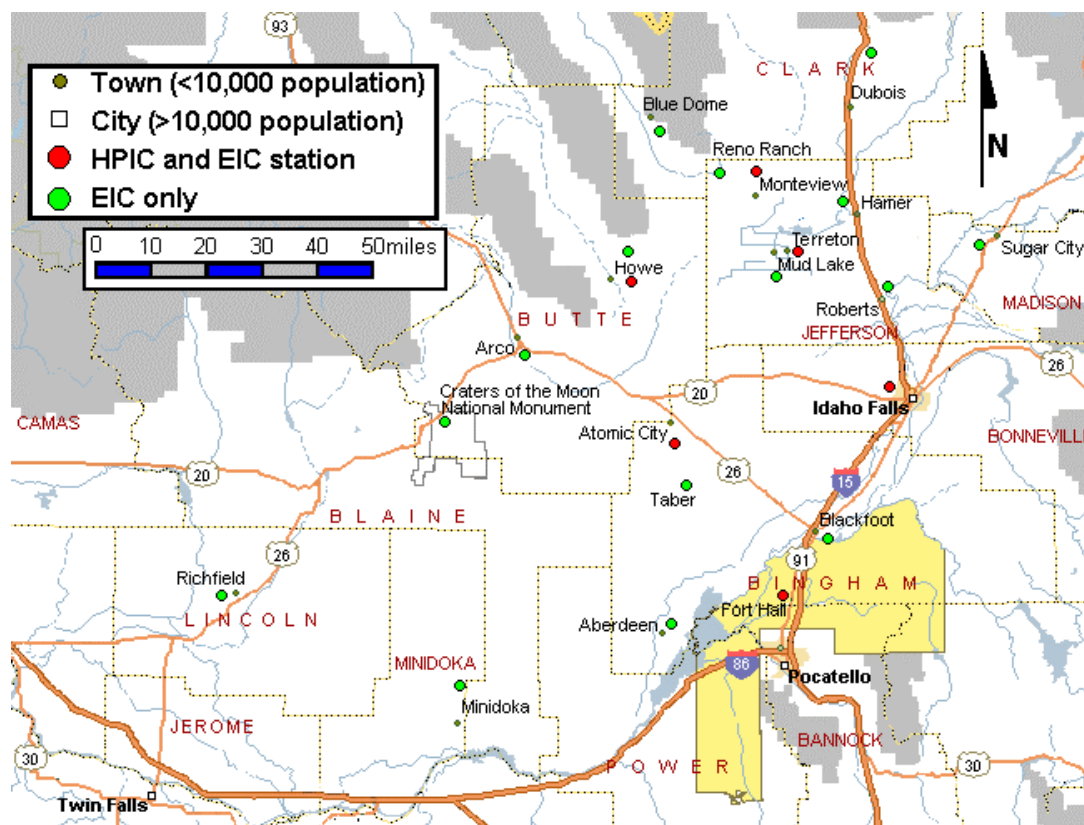


Figure 7-2. Penetrating radiation monitoring stations operated by INEEL OP at (offsite) INEEL boundary locations and distant locations

Radiation measurements that are corrected for elevation response (cosmic radiation effect) compare moderately well (**Table 7-1**) with estimated response (with respect to the *in-situ* measurement results).

¹ Cosmic ray instrument response was estimated from elevation correction factors listed in the operator's manual for the GE Reuter-Stokes, RSS-1013 Environmental Radiation Monitoring Station, version 1.4, May 1993.

² Exposure rates were estimated from dose conversion factors listed in Table 5.1 of the National Council on Radiation Protection and Measurements (NCRP), "Exposure of the Population of the United States and Canada from Natural Background Radiation," NCRP Report Number 94, 1987.

Table 7-1. Estimated HPIC response from NCRP 94 and cosmic ray response, corresponding action level, average HPIC response observed during 2002, and 2002 *in-situ* gamma spectroscopy estimated exposure rate (corrected for cosmic ray response)

| HPIC Location | Estimated Response (μR/h) | Corresponding Action Level (μR/h) | 2002 Average Response (μR/h) | <i>In-situ</i> Gamma Spectroscopy Estimated Response (μR/h) |
|--------------------------|---------------------------|-----------------------------------|------------------------------|---|
| Atomic City | 18.0 ± 1.0 ^a | 36.0 | 12.2 | 16.6 |
| Base of Howe Peak | 18.3 ± 1.6 | 36.6 | 11.2 | 13.9 |
| Big Lost River Rest Area | 15.7 ± 1.2 | 31.4 | 13.1 | 15.8 |
| Big Southern Butte | 12.9 ± 0.6 | 25.8 | 12.3 | 13.6 |
| Howe | 13.3 ± 0.6 | 26.6 | 12.1 | 13.3 |
| Idaho Falls | 14.3 ± 1.3 | 28.6 | 10.9 | 13.9 |
| Main Gate | 15.0 ± 0.6 | 30.0 | 13.7 | NA ^b |
| Mud Lake/Terreton | 13.3 ± 0.6 | 26.6 | 13.1 | 13.3 |
| Montevue | 12.3 ± 0.6 | 24.6 | 11.4 | 12.1 |
| Rover | 15.8 ± 1.2 | 31.6 | 12.9 | 16.6 |
| Sand Dunes Tower | 18.1 ± 1.4 | 36.2 | 12.6 | 13.8 |

^a Estimated 1-sigma uncertainty
^b Not available, *in-situ* measurement not performed during 2002.

During the past two years, the HPIC and EIC measurements have correlated quite well. Differences are due to the energy sensitivity of the two instrument types. The HPIC is made of stainless steel which attenuates low energy x-rays more drastically than the plastic EIC. This accounts for an over response of the EIC by 20 to 40 percent depending upon the distribution of radionuclides in the soil. Average quarterly responses from onsite, boundary, and distant locations are shown in **Figure 7-3**. Average quarterly responses from HPICs and EICs during 2002 from onsite, boundary, and distant locations are found in **Table 7-2** and **Table 7-3**, respectively. Exposure rate measurements in excess of the location specific action levels for HPIC measurements were not exceeded by either the HPICs or the EICs. Descriptive statistics for HPIC and EIC measurements made during 2002 are shown in **Table 7-4**.

For most of 2002, the HPIC network operated properly. Software and communication problems still plague the polling system that collects HPIC data via radiotelemetry at the Idaho Falls office. The high-voltage supply for the HPIC system operated by the Shoshone-Bannock tribes failed early during the second calendar quarter and was not repaired until late in the calendar quarter. An inadequate number of measurements were made using the Fort Hall HPIC to present a representative average exposure rate measurement.

If an EIC was found on the ground or damaged or if the electret were discharged due to improper handling, the measurement was rejected. Several EIC measurements were rejected due to improper handling and damage resulting from grazing animals damaging the Tyvek envelopes used to protect the EIC(s) from the elements. INEEL OP procedures have been modified to remedy this problem during 2003. Primarily, the Tyvek envelopes have been replaced with aluminum cans and multiple (up to three) EICs deployed at each monitoring station to provide replicate analyses for each monitoring location.

Table 7-2. Average exposure rate measurements at routine monitoring stations using high-pressure ion chambers (HPICs). All measurements in micro-Roentgen per hour ($\mu\text{R/h}$)

| Location | 1st Quarter 2002 | 2nd Quarter 2002 | 3rd Quarter 2002 | 4th Quarter 2002 |
|---|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Boundary | | | | |
| Atomic City | 10.0 ± 1.6^a | 12.7 ± 2.5 | 12.8 ± 0.7 | 13.4 ± 1.1 |
| Big Southern Butte | 8.9 ± 1.1 | 13.3 ± 0.4 | 13.5 ± 2.6 | 13.6 ± 1.2 |
| Howe | 11.0 ± 1.1 | 12.2 ± 0.7 | 12.5 ± 0.7 | 12.8 ± 1.0 |
| Montevieu | 9.9 ± 1.2 | 11.9 ± 0.7 | 11.8 ± 0.9 | 12.0 ± 0.9 |
| Mud Lake/Terreton | 11.9 ± 1.4 | 13.3 ± 0.7 | 13.4 ± 0.8 | 13.7 ± 1.0 |
| Boundary Average: | 10.3 ± 1.1 | 12.7 ± 0.6 | 12.8 ± 0.7 | 13.1 ± 0.7 |
| Distant | | | | |
| Fort Hall | 10.9 ± 3.0 | NA ^b | 12.3 ± 1.0 | 11.6 ± 1.5 |
| Idaho Falls | 10.2 ± 1.1 | 11.1 ± 0.7 | 10.9 ± 0.5 | 11.4 ± 0.9 |
| Distant Average: | 10.6 ± 0.5 | 11.1 ± 0.7 | 11.6 ± 0.9 | 11.5 ± 0.1 |
| Onsite | | | | |
| Base of Howe Peak | 9.4 ± 1.8 | 10.4 ± 1.1 | 12.1 ± 1.3 | 12.8 ± 0.9 |
| Main Gate | 11.8 ± 1.4 | 13.5 ± 0.7 | 13.5 ± 0.7 | 14.1 ± 1.0 |
| Big Lost River Rest Area | 11.1 ± 2.0 | 13.6 ± 0.7 | 13.6 ± 0.6 | 13.9 ± 0.9 |
| Rover | 11.4 ± 1.4 | 13.2 ± 0.7 | 13.3 ± 0.7 | 13.7 ± 0.8 |
| Sand Dunes | 11.3 ± 1.4 | 12.8 ± 0.7 | 12.8 ± 0.7 | 13.4 ± 1.0 |
| Onsite Average: | 11.0 ± 0.7 | 12.7 ± 0.4 | 13.1 ± 0.4 | 13.6 ± 0.4 |
| ^a 1-sigma sample standard deviation of HPIC measurements made every 5 minutes. | | | | |
| ^b Data not available due to equipment failure. For this particular case the HPIC high-voltage supply was damaged, therefore readings were unavailable. | | | | |

During 2002, the responses observed using EICs at boundary and distant locations were similar to those observed at onsite locations. Descriptive statistics from the 91 EIC monitoring locations are shown in **Table 7-4**. The descriptive statistics are for the EICs deployed during 2002 by INEEL OP that were not damaged during deployment.

Table 7-3. Average exposure rate measurements at routine monitoring stations using electret ion chambers (EICs). All measurements in micro-Roentgen per hour ($\mu\text{R/h}$)

| Location | 1 st Quarter 2002 | 2 nd Quarter 2002 | 3 rd Quarter 2002 | 4 th Quarter 2002 |
|----------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Boundary | | | | |
| Atomic City | 17.7 ± 1.9^a | 18.2 ± 1.9 | 17.8 ± 1.9 | 18.2 ± 1.7 |
| Big Southern Butte | 20.1 ± 1.9 | 18.6 ± 2.0 | 19.1 ± 1.8 | 26.6 ± 2.3 |
| Howe | 14.6 ± 2.0 | 16.6 ± 1.9 | 17.8 ± 1.9 | 21.5 ± 1.9 |
| Monteview | 15.4 ± 1.8 | 16.7 ± 1.9 | 16.1 ± 2.3 | 18.7 ± 1.8 |
| Mud Lake/Terreton | 18.0 ± 1.9 | 18.5 ± 1.9 | 19.5 ± 2.0 | 20.8 ± 1.8 |
| Boundary Average: | 16.9 ± 5.6 | 17.5 ± 1.6 | 18.4 ± 2.6 | 20.3 ± 5.6 |
| Distant | 17.1 ± 2.2 | 17.7 ± 1.0 | 18.1 ± 1.4 | 21.2 ± 3.4 |
| Craters of the Moon | 14.0 ± 2.2 | 16.3 ± 2.3 | 18.0 ± 2.3 | 17.9 ± 2.1 |
| Ft Hall | 19.4 ± 2.0 | NA ^b | 18.6 ± 1.9 | 18.8 ± 1.8 |
| Idaho Falls | 13.9 ± 1.8 | 14.8 ± 1.8 | 16.0 ± 1.9 | 16.2 ± 2.0 |
| Distant Average: | 16.0 ± 3.0 | 17.4 ± 2.0 | 17.5 ± 3.2 | 19.3 ± 2.7 |
| Onsite | 15.8 ± 3.1 | 15.5 ± 1.1 | 17.5 ± 1.4 | 17.6 ± 1.4 |
| Base of Howe Peak | 17.3 ± 2.3 | 16.6 ± 1.8 | 18.0 ± 1.9 | 20.1 ± 1.9 |
| Big Lost River Rest Area | 17.9 ± 1.9 | 19.3 ± 1.9 | 19.2 ± 1.9 | 22.7 ± 2.3 |
| Experimental Field Station | 19.5 ± 2.4 | 21.5 ± 2.5 | 30.4 ± 2.9 | 24.3 ± 2.4 |
| Main Gate | 19.1 ± 2.1 | 18.1 ± 1.9 | 19.7 ± 2.0 | 23.1 ± 2.0 |
| Rover | 15.5 ± 2.0 | NA ^b | 19.2 ± 2.0 | 19.7 ± 1.9 |
| Sand Dunes | 18.6 ± 1.9 | 18.0 ± 1.9 | 20.4 ± 2.0 | 23.7 ± 2.0 |
| Van Buren Avenue | 17.2 ± 2.3 | 22.6 ± 2.5 | NS ^b | 20.9 ± 2.2 |
| Onsite Average: | 17.8 ± 4.7 | 20.3 ± 3.7 | 20.6 ± 4.3 | 22.4 ± 8.9 |

^a 2-sigma measurement uncertainty^b Not available. The EIC was either stolen, tampered with, or damaged, therefore, no measurement was available.**Table 7-4.** Descriptive statistics of HPIC and EIC measurements made during 2002 at boundary, distant, and onsite locations. Measurements given in terms of average exposure rate or micro-Roentgen per hour ($\mu\text{R/h}$).

| | HPIC Boundary Locations | EIC Boundary Locations | HPIC Distant Locations | EIC Distant Locations | HPIC Onsite Locations | EIC Onsite Locations |
|---------------------|-------------------------------|------------------------------|------------------------------|--------------------------|-----------------------------|-------------------------|
| Average | 12.2 | 17.7 | 11.2 | 17.8 | 12.6 | 21.4 |
| Median | 12.6 | 17.9 | 11.1 | 18.1 | 13.0 | 21.2 |
| Standard Deviation | 1.4 | 2.3 | 0.7 | 2.9 | 1.3 | 3.1 |
| Minimum | 8.9 | 11.7 | 10.2 | 10.6 | 9.4 | 7.8 |
| Maximum | 13.7 | 24.2 | 12.3 | 25.1 | 14.1 | 21.1 |
| Number of Locations | 5 | 11 | 2 | 12 | 5 | 68 |

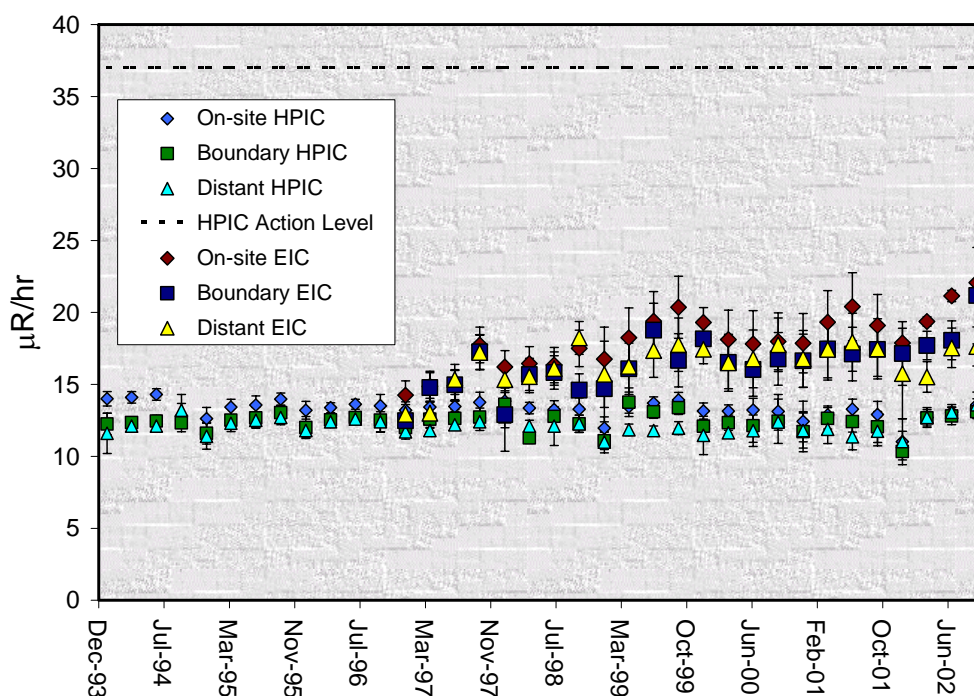


Figure 7-1. Average quarterly exposure rates observed at monitoring stations on the INEEL, near the INEEL boundary, and at distant locations using high-pressure ion chambers (HPICs) and electret ion chambers (EICs). The HPIC action level corresponds to twice the expected background measurement based upon 2002 *in-situ* gamma spectroscopy measurements and cosmic ray contributions estimated from elevation.

Comparison of External Radiation Monitoring Results Reported by DOE Contractors

Ambient penetrating radiation measurements that were made by the INEEL OP during 2002 agreed moderately well with measurements made by DOE-ID contractors during that time. Differences were expected due to differences in monitoring schedules and in methods used by each organization for environmental dosimetry.

The INEEL OP does not co-locate high-pressure ion chambers (HPICs) near DOE-ID contractor HPICs. To verify INEEL OP HPIC measurements, *in-situ* gamma spectroscopic measurements were made at 10 of the 12 radiation monitoring sites equipped with HPICs. Since HPICs are not co-located, a direct comparison between INEEL OP HPIC measurements and DOE-ID measurements was not appropriate.

Several electret ion chambers (EICs) operated by INEEL OP are co-located with DOE-ID thermoluminescent dosimeters (TLDs) used to monitor penetrating radiation. The TLDs deployed by DOE are deployed for a period of six months (May to November), whereas the EICs

deployed by INEEL OP are deployed for a period of three months (calendar quarter). Differences are expected due to variations in monitoring schedules and differences between the types of environmental dosimeters used. Historically, the EICs used by INEEL OP have been expected to be more sensitive to low-energy x-ray and gamma photons and have shown between 10 and 20 percent greater response than the TLDs used by DOE-ID. **Table 7-5** shows a summary of comparisons between INEEL OP and DOE contractors during 2001 and 2002.

Table 7-5. Descriptive statistics of environmental dosimetry comparison results for 2001 and 2002 between INEEL and DOE-ID contractors for monitoring environmental penetrating radiation

| | INEEL OP Exposure (mR) | BBWI Exposure (mR) | INEEL OP Exposure (mR) | ESER Exposure (mR) |
|--|------------------------------|--------------------------|------------------------------|--------------------------|
| Average: | 89.3 | 67.3 | 74.6 | 62.4 |
| Median: | 89.4 | 67.1 | 73.3 | 61.5 |
| Standard Deviation: | 13.2 | 5.9 | 9.0 | 6.1 |
| Minimum: | 64.5 | 51.1 | 60.1 | 51.7 |
| Maximum: | 144.1 | 84.0 | 96.1 | 75.1 |
| Number of Paired Samples: | 89 | | 48 | |
| Percent agreement (Relative Difference): | 88.8% | | 93.8% | |
| Percent agreement (3-sigma): | 75.3% | | 85.4% | |
| Average Relative Difference: | 13.7% | | 9.7% | |

References

- National Council on Radiation Protection and Measurements. *Exposure of the Population in the United States and Canada from Natural Background Radiation*. NCRP Report Number 94, 1987.
- Reuter-Stokes. *RSS-1013 PIC Environmental Radiation Monitoring Station Operational Manual*. Version 1.4, May 1993.

Chapter 8

Quality Assurance/Quality Control

INEEL Oversight Program QA/QC for Environmental Surveillance Measurements

This section summarizes the QA/QC samples (spikes, blanks, and duplicate), submitted to the IBL for nonradiological analyses and to the ISU EML for radiological analyses for 2002. In addition, this section includes any corrective actions that were identified or implemented for the ESP.

All analyses and QA measures in the analytical laboratories are performed in accordance with approved written procedures maintained by each respective analytical laboratory. Sample collection is performed in accordance with written procedures maintained by the INEEL OP.

The ISU EML reported a suspected laboratory tritium contamination problem for both third and fourth quarters of 2001. For 2002, tritium contamination was not a problem with respect to analysis results.

External spiked samples for radiological analytes were not submitted during 2002 pending the development of an external, round-robin, spiked sampling program involving DOE-ID sampling programs conducting environmental surveillance.

Sample tracking problems resulted in the rejection of analysis results for spiked dissolved nutrient samples. Total alkalinity, nitrate plus nitrite, and fluoride analyses results for blank samples were also problematic, as well as the rejection of 23 fluoride analyses due to laboratory issues.

Duplicate sample results submitted by the INEEL OP do not indicate any laboratory bias or problems. However, several gross beta screening results for blank PM₁₀ samples indicate a slight negative bias.

Corrective actions that were identified and initiated are changes in IBL laboratory procedures to insure that the laboratory check the pH of the samples for assurance that the samples are labeled properly and that the laboratory calls the sampler when there is any anomaly with the samples.

Quality Assurance Program

The measurement of any physical quantity is subject to uncertainty from errors that may be introduced during sample collection, measurement, calibration, and the reading and reporting of results as well as natural variation in the quantity measured. While the sum of these inaccuracies cannot be quantified for each analytical result, a quality assurance program can evaluate the overall quality of a data set and possibly identify and address errors or inaccuracies.

Air Monitoring Quality Assurance/Quality Control

Quality control for the air monitoring program is maintained through adherence to INEEL OP standard operating procedures. The INEEL OP routinely conducts quality control checks for all field air sampling measurements and laboratory analyses. Air flow rates and volume measurements for particulate samplers and atmospheric moisture samplers receive annual performance evaluations. Air sample results are reviewed for adequate sample volume before final results are calculated.

Quality control checks also involve the preparation of external field blanks and internal laboratory protocols. Field blanks are prepared weekly for the air particulate filters and quarterly for atmospheric moisture samples. The laboratory's internal protocols include instrument performance checks, sample recounts, and cross-check programs.

Gamma Radiation Monitoring Quality Assurance/Quality Control

Quality control for the gamma radiation monitoring program is maintained through adherence to the INEEL OP standard operating procedures. The INEEL OP routinely conducts quality control checks for all gamma radiation instrumentation and analyses. Each quarter, INEEL OP has EICs irradiated with known gamma exposures for QA purposes. Irradiations of EICs are conducted by ISU EML to a known exposure of 30 milliRoentgen (mR) plus a "blind" exposure of 20 to 50 mR. EIC response is considered acceptable if the measured exposure is within 10 percent or 3 standard deviations of the actual exposure. In addition, each quarter a second EIC is placed at some monitoring sites to evaluate the reproducibility of the exposure measurement.

The response of each HPIC is verified annually in the field with a radiation source and a calibrated reference instrument. At every location, side-by-side measurements are made of the source with the reference instrument and with the HPIC. Whenever these measurements do not agree to within 10 percent, the HPIC is removed and returned to the manufacturer for service and calibration.

Terrestrial Monitoring Quality Assurance/Quality Control

Quality control for the terrestrial monitoring program is maintained through adherence to the INEEL OP standard operating procedures. Laboratory quality assurance and quality control methods include the use of calibration standards, laboratory-prepared spikes, and other technical practices and protocols.

Water Monitoring Quality Assurance/Quality Control

Quality control for the water monitoring program is maintained through adherence to INEEL OP standard operating procedures. To verify the accuracy and precision of the laboratory analyses, INEEL OP obtains analytical results of field duplicates of radiological water samples and both field duplicates and spiked samples of non-radiological water samples.

Blanks, Spikes, and Duplicates

Analytical results for blanks, spikes, and duplicates are used to assess the precision, accuracy, and representative nature of results from analyzing laboratories. During 2002, the INEEL OP submitted 268 QA/QC samples for various radiological and nonradiological analyses. Detailed data tables can be found in each of the quarterly reports for the sampling year 2002.

Blank Samples

Blank samples have negligible, acceptably low, or non-measurable amounts of the analyte(s) of interest in them. They are designed to determine if analyses will provide a “zero” result when no contaminant is expected to be present, and therefore, monitor any bias that may have been introduced during sample collection, storage, shipment, and analysis. Matrix blanks include field and transport blanks with custody seals.

Gross Alpha and Beta Screening

During 2002, the INEEL OP submitted 59 blank samples for gross alpha and beta screening. The blank samples consisted of PM₁₀ filters and water samples. Ninety-six percent of the blank PM₁₀ filters submitted for gross alpha analyses were within 2 standard deviations of a “zero” result (**Figure 8-1**)

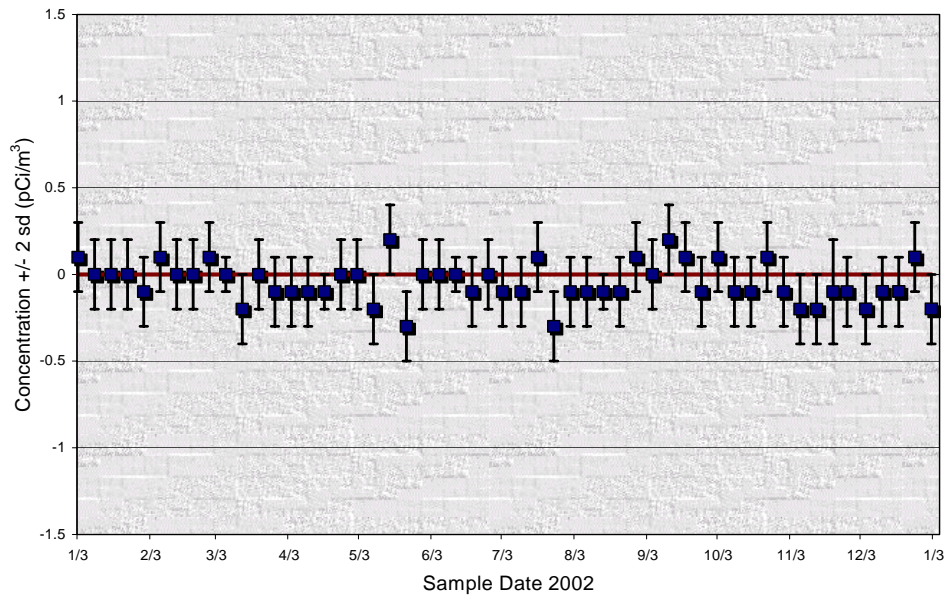


Figure 8-1. Blank PM₁₀ alpha

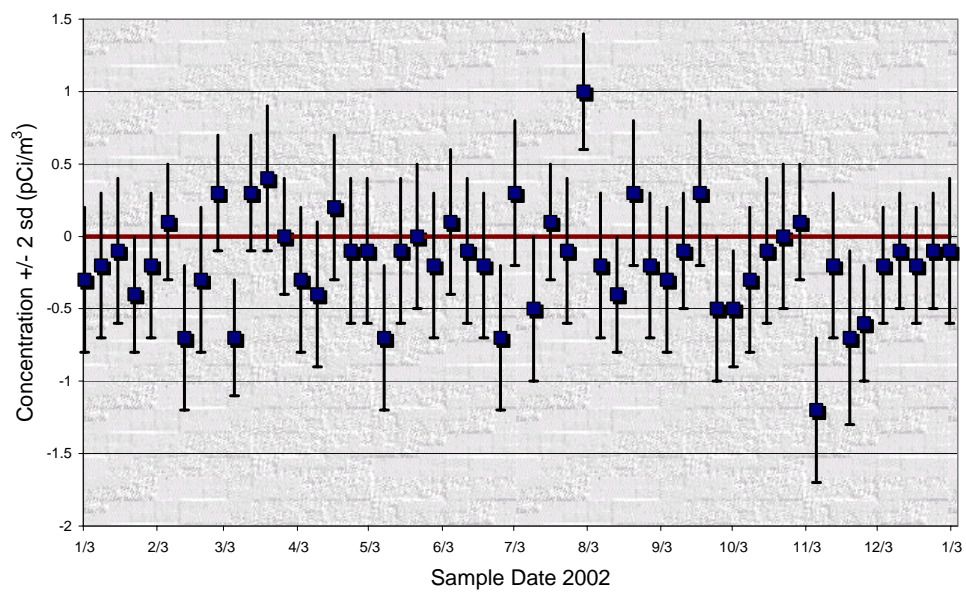


Figure 8-2. Blank PM₁₀ beta

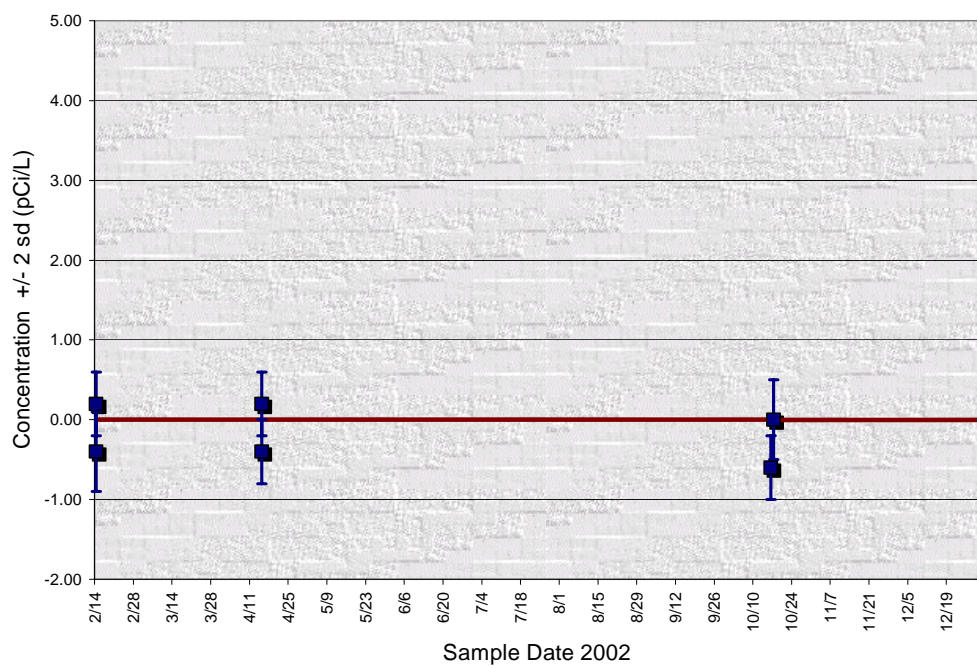


Figure 8-3. Blank water alpha

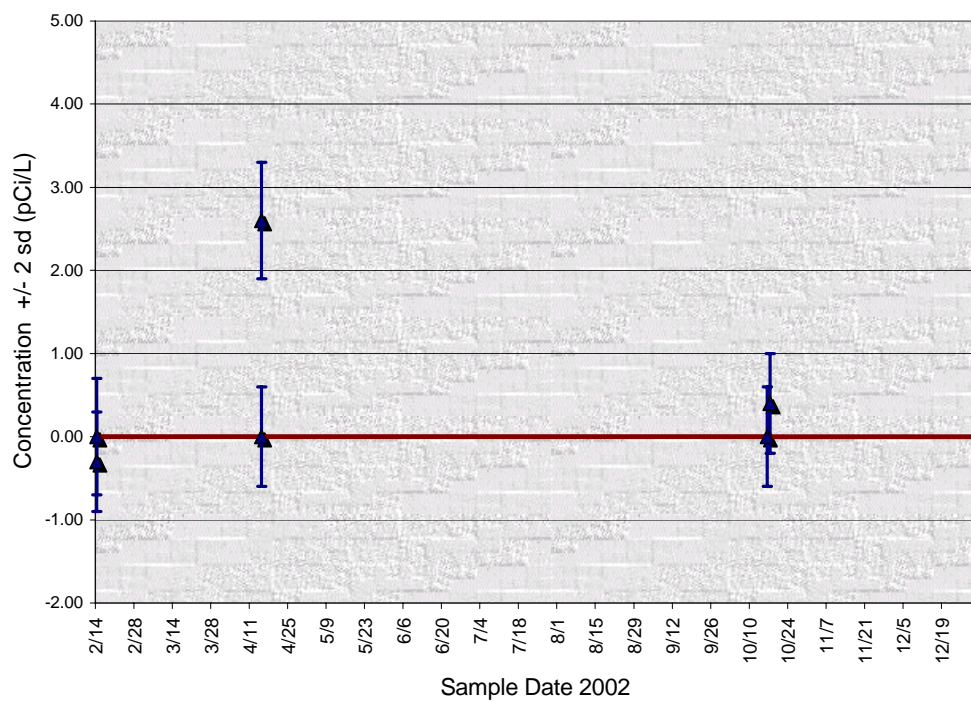


Figure 8-4. Blank water beta.

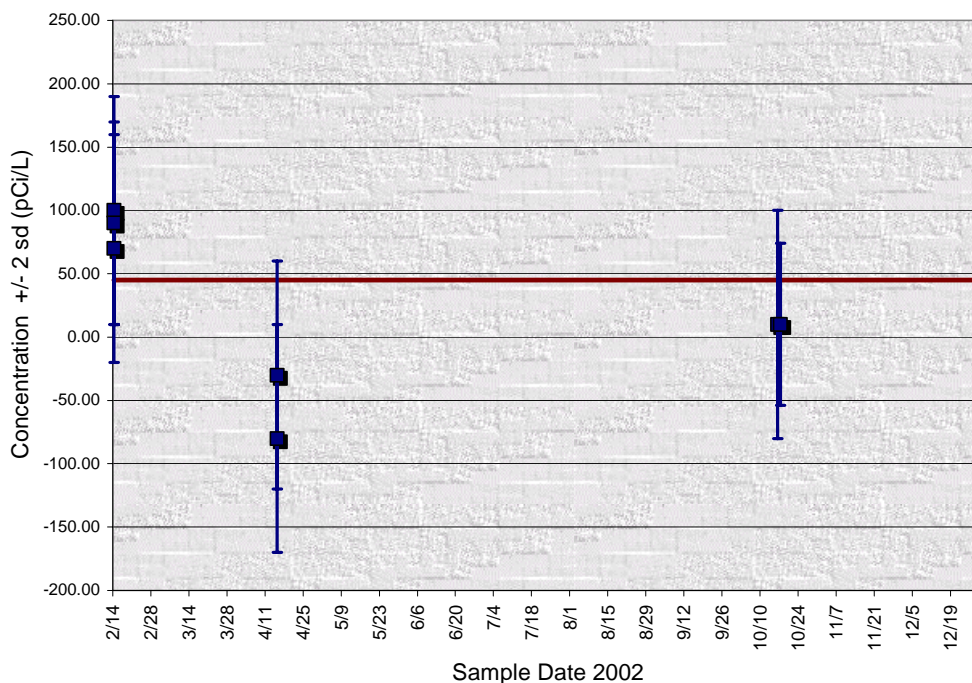


Figure 8-5. Blank water tritium

Eighty-three percent of the blank PM₁₀ filters submitted for gross beta analyses were within 2 standard deviations of a “zero” result. A majority of those results that did not meet the criteria were less than zero, indicating a slight negative bias.

For blank water samples, 100 percent of the gross alpha screening results were within 2 standard deviations of the “zero” result, and 86 percent of the gross beta screening results were within 2 standard deviations of the “zero” result.

Gamma Spectroscopy

During 2002, the INEEL OP submitted 14 blank samples for gamma spectroscopy analysis. The blank samples consisted of PM₁₀ filter composites and water samples. For 2002, all of the blank samples submitted for gamma spectroscopy analysis were within 2 standard deviations of the “zero” result.

Tritium Analysis

During 2002, the INEEL OP submitted 7 blank water samples for tritium analysis. Natural background tritium levels in water are on average 45 pCi/L. This value is considered the “zero” result. Eighty-six percent of the blank water samples submitted for tritium analysis were within 2 standard deviations of 45 pCi/L.

Nonradiological Analyses

Results for total alkalinity exceeded the detection level of 1 mg/L for three samples submitted during the third and fourth quarters of 2002. Since all total alkalinity results for that sample period were greater by factors of 50 or more when compared to the blank analyses results, no qualifiers were required.

One nitrate plus nitrite result sampled during the second quarter of 2002 showed a detectable concentration. Reported levels for all other samples submitted and analyzed at the sample time were significantly higher as well. Thus, no qualifiers were required.

During the second quarter of 2002, one of the fluoride analysis results yielded a detectable concentration. The fluoride results analyzed on the same date prior to the blank sample with the detection were qualified as “J” or estimated. For the verification sampling, 23 of 35 fluoride analyses results were rejected due to laboratory issues. Investigation results will be available once the cause is discovered.

No other common ions and nutrient analyses were detected in blank samples.

Spike Results

Spikes are samples to which known concentrations of specific analytes have been added. One indicator of agreement is the difference between the known concentration in the sample and the measured concentration, expressed as a relative percent difference. This quantity is calculated and averaged to give an average bias. The standard deviation of the differences can be used as an indicator of the overall precision of the dataset.

During 2002, the INEEL OP submitted spikes for various nonradiological analyses. A total of 18 samples spiked with 13 analytes were submitted to the IBL. Results were returned for 16 of the 18 samples.

Problems were encountered during 2002 with respect to spiked samples. Results for dissolved nutrients submitted during the second quarter were rejected due to unresolved questions relating to sample tracking. Review of all other data for that specific sampling quarter did not indicate other sample results that may have been misidentified with the spiked sample. In addition, the instrument used for fluoride analysis had failed and a new method based on ion chromatography had not been completed. The samples were not analyzed because the time to develop the new method would have substantially exceeded the sample holding time. These results are included with no result or detection level reported and qualified as “R” with an appropriate comment.

All spiked sample results for the remaining 16 samples were within control limits.

External spiked samples for radiological analytes were not submitted during 2002 pending the development of an external, round-robin, spiked sampling program involving DOE-ID sampling programs conducting surveillance.

Electret Ion Chambers

To verify EIC response, INEEL OP has EICs irradiated with known and “blind” gamma exposures. For quality assurance (QA) purposes, ISU EML conducts QA irradiations to a known exposure of 30 mR and a “blind” exposure ranging from 20 to 50 mR (“blind” in the context that INEEL OP does not know the exposure received until after the analysis is performed). EIC response using the factory E-PERM™ calibration factors is compared directly with the exposure received from the NIST traceable cesium-137 source used by ISU EML for these irradiations. EIC response is considered acceptable if each irradiated EIC agrees within 10% or within 3 standard deviations. Irradiation results for 2002 are shown in **Table 8-1**, and **Figure 8-6** shows a graphic representation of EIC results with exposure received.

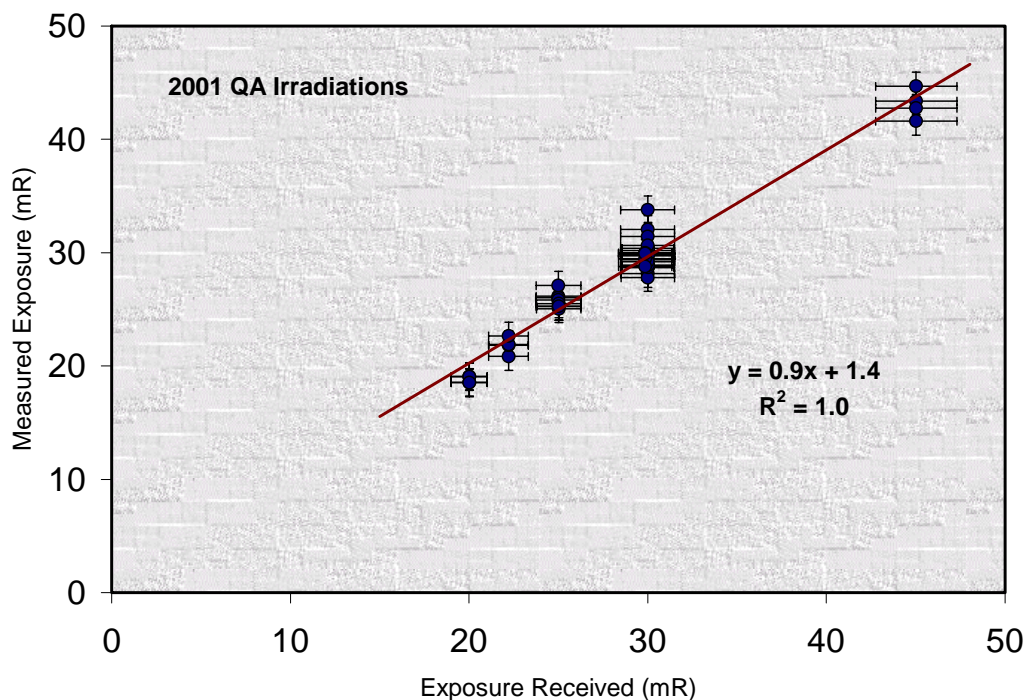


Figure 8-6. Internal QA irradiation results of EICs conducted in 2002. Electret ion chambers were irradiated by ISU EML.

Table 8–1. Quality assurance irradiation summary of EICs conducted in 2002

| | "Measured" Exposure (mR) | "Known" exposure (mR) | Relative Difference |
|---|-----------------------------|--------------------------|---------------------|
| 1 st Quarter 2002 ("known") | 30.72 ± 0.8 ^a | 30.0 ± 1.5 | 2.3% |
| 1 st Quarter 2002 ("blind") | 44.4 ± 1.3 | 45.0 ± 2.3 | -1.4% |
| 2 nd Quarter 2002 ("known") | 29.7 ± 1.2 | 30.0 ± 1.5 | -1.0% |
| 2 nd Quarter 2002 ("blind") | 37.5 ± 0.7 | 37.0 ± 1.9 | 1.4% |
| 3 rd Quarter 2002 ("known") | 30.2 ± 0.8 | 30.0 ± 1.5 | 0.7% |
| 3 rd Quarter 2002 ("blind") | 41.7 ± 0.2 | 42.0 ± 1.9 | -0.8% |
| 4 th Quarter 2002 ("known") | 28.4 ± 3.0 | 30.0 ± 1.5 | -5.2% |
| 4 th Quarter 2002 ("blind") | 44.2 ± 0.9 | 45.0 ± 2.3 | -1.8% |
| Overall Relative Difference: | | | -0.73% |
| ^a Propagated 1-sigma measurement uncertainty | | | |

High-Pressure Ion Chambers

Annual source checks were conducted at each HPIC deployed as part of the penetrating radiation monitoring network. The source check involves the direct comparison of instrument response to a gamma source between the HPIC deployed in the field and a "mobile" HPIC calibrated by the manufacturer. The results of this source check are shown in **Table 8-2**. Variation in HPIC response between different generations of HPICs deployed by INEEL OP is being investigated. The relative positioning of the 10 μ Ci cesium-137 source with respect to the chamber inside the protective housing may be responsible for the observed differences in instrument response.

Table 8–2. 2002 summary of HPIC source field checks

| Location | Date Performed | Relative Difference with Respect to the Calibrated HPIC |
|-------------------------------------|----------------|---|
| Atomic City | 7/24/02 | -2.7% |
| Base of Howe | 8/13/02 | -0.8% |
| Big Lost River Rest Area | 7/22/02 | -4.5% |
| Big Southern Butte | 7/01/02 | 4.4% |
| Fort Hall CMS | 9/05/02 | 5.4% |
| Howe Met Tower | 7/17/02 | -3.5% |
| Idaho Falls | 6/24/02 | -3.1% |
| Main Gate | 8/13/02 | -0.1% |
| Monteview | 7/10/02 | 2.0% |
| Mud Lake | 6/26/02 | -5.0% |
| Rover | 8/27/02 | -0.9% |
| Sand Dunes Tower | 7/17/02 | -4.8% |
| Average Relative Difference: | | -1.1% |

Duplicate Results

Duplicate samples are collected in a manner such that the samples are thought to be essentially identical in composition and are used to assess analytical precision.

Radiological analyses

During 2002, the INEEL OP submitted 14 duplicate samples for radiological analyses. Unlike the nonradioactive constituents for which no analytical uncertainty is reported, the counting uncertainty must be considered when evaluating the reproducibility of radioactivity analyses.

The results reported for the duplicate sample sets were considered to be within control limits for precision if:

$$|R_1 - R_2| \leq 3 (s_1^2 + s_2^2)^{1/2}$$

where,

R_1 = concentration of analyte in the first sample

R_2 = concentration of analyte in the duplicate sample

S_1 = sample standard deviation of the first sample

S_2 = sample standard deviation of the duplicate sample

or,

The Relative Percent Difference (RPD) was less than or equal to 20 percent.

If less than 90 percent of the duplicate analyses meet these criteria, further evaluation is conducted to determine whether a corrective action is necessary.

The gross alpha and gross beta radioactivity in the duplicate sample set for MV-01 was not within control limits.

Nonradiological analyses

During 2002, the INEEL OP submitted 12 duplicate samples for various nonradiological analyses. If the reported concentration of the analyte exceeded the detection limit by a factor of five or more in a sample and corresponding duplicate, the laboratory precision was determined by calculating the RPD between the two analytical results using the following equation:

$$RPD = \frac{|R_1 - R_2|}{\frac{(R_1 + R_2)}{2}} \times 100$$

Where

R_1 = concentration of analyte in the first or primary sample

R_2 = concentration of analyte in the duplicate sample.

For duplicate sample sets in which one or both of the results reported for a particular analyte were less than five times the detection limit, the level of precision was considered acceptable if the two results differed by an amount equal to or less than the detection limit. If less than 90 percent of the duplicate sample sets for a particular analyte meet the desired level of precision, the results are discussed with the laboratory to determine whether a corrective action is required.

Duplicate samples for 2002 were within control limits with the exception of one duplicate analysis result for nitrate plus nitrite as nitrogen and three duplicate analysis results for fluoride.

External QA/QC

During 2002, the INEEL OP did not participate in external QA/QC programs. An external round-robin spike sample program involving DOE-ID sampling programs conducting surveillance sampling is under development but has not yet been implemented. The EML, however, participated in the “Interlab RadChemTM Proficiency Testing Program.” Three analyses were conducted for three water samples for gross alpha, gross beta, and tritium, and two analyses for gamma. Only one result for gross beta did not meet specifications.

Corrective Actions

There were a few issues that required corrective actions by either the analysis laboratories or INEEL OP.

Apparent laboratory sample tracking errors contributed to a spiked sample and regular sample results being switched. Arrangements were made to insure that the laboratory checks the pH of the samples for assurance that the samples are labeled properly and that the laboratory calls the sampler when there is any anomaly with the samples. While no corrective action can remove the potential for any mix occurring in the future, open lines of communication should reduce the likelihood of such errors, as will increased diligence and attention to details in the field and during sample preparation for shipping. In addition, corrective actions taken by the IBL to correct fluoride analyses problems appear to have remedied the situation.

Corrective actions from 2001 included ISU moving its tritium sample preparation to another building, where tritium contamination does not appear to be a problem. The tritium contamination problem that plagued analyses in 2001 does not appear to be a problem for 2002. No other corrective actions were necessary.

Appendix A

The Design and Development of the INEEL Oversight Program's Environmental Surveillance Program

History and Legislative Authority

In the late 1980s, at a time when facts about contamination from a half century of defense-related production were gradually coming to light, and DOE's credibility with state governments was consequently deteriorating, the U.S. Secretary of Energy proposed the concept of oversight roles for states hosting DOE facilities. Under this new proposal, the states would be given access to DOE facilities and information so that each state could conduct independent assessments of the potential environmental impacts resulting from DOE activities. The details of such arrangements were to be negotiated in agreements-in-principle (AIP), wherein DOE would obligate funds to ensure that states could carry out their oversight responsibilities.

On April 5, 1989, the Idaho Legislature enacted Senate Bill 1266, establishing a comprehensive oversight program for the INEEL, and on May 1, 1990, the state of Idaho and the DOE signed a five-year AIP entitled the Environmental Oversight and Monitoring Agreement (State of Idaho-DOE 1990). This agreement provided grant funding and other resources for establishing and supporting the state's INEEL OP, which was assigned the following responsibilities:

- Secure necessary data and information regarding DOE activities in Idaho;
- Scientifically evaluate this information in the context of total INEEL impacts on the public and environment; and
- Objectively report conclusions to the people of Idaho.

When the first AIP grant expired in 1995, the state of Idaho, DOE, and Naval Reactors negotiated a subsequent five-year AIP, which reinforced the fundamental elements of the program and built on the experience gained during the first five years of INEEL OP operations. INEEL OP, the DOE and NRF negotiated another subsequent five-year AIP in 2000.

By working cooperatively with DOE, INEEL OP has developed a successful program that includes a strategic monitoring network designed to supplement and verify DOE's environmental monitoring data, which allows the state of Idaho to provide independent oversight and surveillance of the environment and DOE activities at the INEEL.

Environmental Surveillance Program Network Design

The INEEL OP surveillance network selectively and independently collects samples of environmental media that could be contaminated by activities at the INEEL. Media sampled include air, surface water, groundwater, soil, and milk. The evolution of the INEEL OP monitoring network is summarized below.

Air Monitoring

The INEEL OP air monitoring network was created through a research and development agreement with DOE to conduct independent air monitoring activities on and around the INEEL.

By evaluating meteorological records, results from dispersion models, and the locations of actual or potential air emission sources at INEEL, the program identified potential offsite locations for six permanent air quality monitoring stations. Four of these sites were situated around the perimeter of the INEEL at Mud Lake, Montevue, Howe, and Atomic City. A fifth site was established on the INEEL at the Big Lost River Rest Area on U.S. Highway 20/26. Initially, these five sites were equipped with low-volume particulate samplers loaned to the INEEL OP by the U.S. Environmental Protection Agency (EPA). In 1992, these samplers were replaced with similar samplers, acquired from DOE's contractor surplus, which INEEL OP operated according to QA/QC and standard operating procedures. The sixth site, in Idaho Falls, was added to the network in the fall of 1992 to serve as a distant background monitoring location. Collectively, these six stations now serve as permanent monitoring stations in the air surveillance program.

In January of 1994, following DOE's decision to privatize its environmental surveillance program, the INEEL OP incorporated the four ISU Environmental Monitoring Program

air-monitoring stations into its network. These stations, previously operated by ISU for DOE, included three locations on the INEEL--Sand Dunes Tower, Experimental Field Station, and Van Buren Avenue, and one offsite location at the Craters of the Moon National Monument. **Figure 2-1** in **Chapter 2** of this report provides the locations of these sites.

The network instrumentation of the ten air monitoring stations included samplers to collect airborne particulate matter smaller than ten micrometers in diameter (PM₁₀), atmospheric moisture, and gaseous radioiodine. However, after a two-year investigation comparing high-volume total suspended particulate (TSP) air samplers to the PM₁₀ samplers, the TSP samplers were selected as a suitable replacement. Precipitation samplers operate at six of the ten monitoring stations to collect samples for radiological analyses.

External Radiation Monitoring

Each of the ten air monitoring stations described above is further equipped with an environmental dosimeter to measure time-integrated exposure to gamma radiation. For real-time measurement of ambient gamma radiation, the six original stations also employ high-pressurized ion chambers, from which data can be relayed via radio transmitter to the INEEL OP Idaho Falls office.

Expanding the radiation monitoring network in 1995, the INEEL OP applied historical meteorological data and dispersion modeling information to the process of selecting strategic locations for additional radiation monitoring stations. Now in place at Rover, near the eastern site boundary and southwest of Mud Lake, the Base of Howe Peak, the Main Gate, and near Big Southern Butte, these stations include both environmental dosimeters and high-pressurized ion chambers, and, with the exception of the Main Gate location, are powered by solar energy. The locations of these sites are shown on **Figure 2-2** in **Chapter 2** of this report.

In 1999, the INEEL OP implemented a new type of environmental dosimeter to replace the thermoluminescent dosimeters previously used. Electret ion chambers (EIC) were deployed at the six original stations, the four stations formerly operated by ISU, and Rover, the Base of Howe Peak, the Main Gate, and near Big Southern Butte. In addition, EICs are deployed around the perimeter of the INEEL approximately every two miles and at NOAA mesonet towers throughout southeastern Idaho for a total of 91 locations. The locations of these sites are shown on **Figure 2-2** in **Chapter 2** of this report.

Terrestrial Media Monitoring

Deposition of radioactive material released from INEEL facilities to the air can cause accumulation and migration of radionuclides in the environment that may lead to human exposure or adverse environmental impacts. Terrestrial media that can be sampled to assess potential human and environmental exposure to deposited radioactive material includes, but is not limited to soil, vegetation, and milk.

The methodology used by the INEEL OP to identify terrestrial monitoring locations included an assessment of potential INEEL facility air emission characteristics, the evaluation of monitoring activities by other agencies, and careful consideration of INEEL OP objectives. Initially, soil monitoring locations were selected to further characterize the environment around the permanent air monitoring stations. Co-locating these two sampling activities supported comparisons of related background and long-term data trends. Periodically, an *in-situ* gamma spectrometer could be employed to determine background radiation information at co-located sampling locations.

Water Monitoring

Contamination of the Snake River Plain Aquifer underlying the INEEL is generally limited to areas near TAN, INTEC, TRA, CFA, and RWMC as shown in **Figure A-1**. In these areas, the concentration of one or more contaminants in the aquifer approaches or exceeds federal drinking water standards. Because the USGS has been monitoring water quality at the INEEL since 1949, many of the more than 300 wells presently used to monitor the Snake River Plain Aquifer in the vicinity of the INEEL are observation wells originally installed by the USGS.

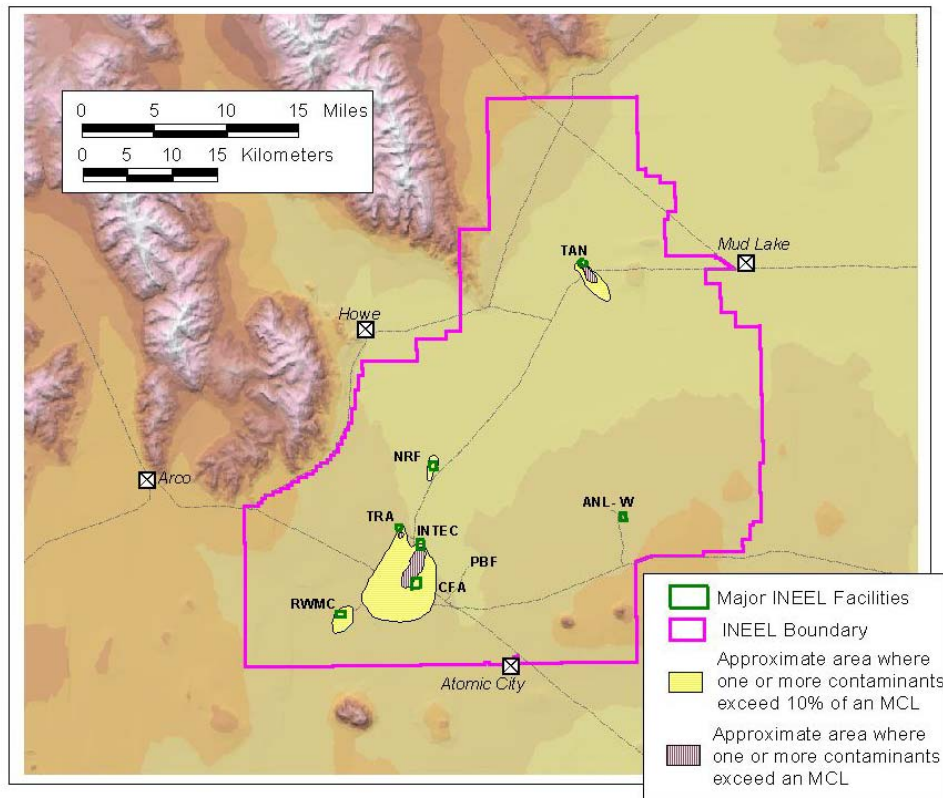


Figure A-1. Plume map showing areas of contamination of the Snake River Plain Aquifer at the INEEL

The INEEL OP water surveillance network combined two previously existing surveillance programs in 1993. The first, established by the ISU Environmental Monitoring Program in 1989, had previously conducted replicate sampling with DOE contractors and the USGS INEEL Project Office at 23 locations on and off the INEEL. The second, a cooperative program between the USGS and the Idaho Department of Water Resources (IDWR), performed sampling to determine the quality of water in the Snake River Plain Aquifer between the southern boundary of the INEEL and the Thousand Springs area along the Snake River near Hagerman. Merging these two surveillance programs, the INEEL OP assumed monitoring responsibilities from the ISU Environmental Monitoring Program, funded a position in IDWR to cover the expenses of collecting samples south of the INEEL, and implemented a three-year rotation sampling schedule for 55 sites. In addition, the INEEL OP water surveillance program initiated a new sampling program in 1999 to co-sample wastewater and groundwater collected by BBWI, ANL-W and NRF on the INEEL.

Over the past five years, the INEEL OP has expanded the number of monitoring locations originated by the surveillance programs and will continue to selectively add wells or springs to the network when one or more of the following criteria are met:

- Water from the location is used by the public;
- The location provides long-term community monitoring trends;
- Sampling from the location verifies and supplements monitoring by the INEEL contractor; and/or
- The location provides information at critical points along the groundwater pathway.

Currently, the INEEL OP collects water samples from 76 wells, 8 springs, and 3 surface water locations on and off the INEEL. With regard to the wastewater and groundwater sampling in 2002, 33 sites were sampled. Additional information regarding the locations, sampling schedules, and co-sampling organizations associated with the water monitoring program is provided in **Chapter 2** of this report.

Appendix B:

Glossary, Acronyms and Units

Glossary

A priori—Prior to measurement.

Accuracy—The degree of agreement of a measured value with the --true-- or expected value.

Activation products—Isotopes produced from the absorption by nuclei of neutrons in a nuclear reactor.

Activity—See radioactivity.

Alpha particle—Particle that is emitted from the nucleus of an atom, and contains two protons and two neutrons. Identical to the nucleus of a helium atom, without the electrons, an alpha particle is a form of radiation that can travel only a few millimeters in air, and be stopped by a piece of paper. Uranium-238, radium-226, and polonium-210 are all alpha emitters.

Atom—The smallest particle of an element that retains all the chemical and physical characteristics of that element. Every known atom consists of negatively charged electrons traveling around a nucleus. The nucleus, or core, of an atom contains protons, which are positively charged, and neutrons, which are uncharged.

Atomic weight—A number that identifies a specific isotope numerically equal to the number of protons and neutrons in the isotope. For example, the “90” in strontium-90 indicates a total of 90 protons and neutrons in the nucleus.

Background—Naturally occurring or constantly present radioactivity or chemical species in an environment. Cosmic rays and terrestrial radiation are two contributors to natural background.

Beta particle—A high-speed particle, identical to an electron, that is emitted from the nucleus of an atom. Beta radiation can be stopped by a thin sheet of metal about the thickness of foil. Strontium-90, cesium-137, and tritium are beta emitters.

Committed effective dose equivalent—The dose equivalent that will accumulate during the 50 years following the intake of a radionuclide.

Confidence interval—The range of values that may be expected to encompass the true value.

Cosmic radiation—Radiation which permeates all of space, from sources primarily outside our solar system. The radiation is in many forms, from high-speed, heavy particles to high-energy photons. Examples of cosmogenic radionuclides are carbon-14, tritium, and beryllium-7.

Cosmogenic radioactivity—Unstable atoms resulting from the interaction between cosmic radiation and atoms in the atmosphere. Examples of cosmogenic radionuclides include carbon-14, tritium, and beryllium-7.

Decay—The spontaneous transformation of one nuclide into a different nuclide or a different energy state of the same nuclide. For a radioactive nuclide, this transformation process results in the emission of nuclear radiation, such as alpha, beta, or gamma radiation.

Decay chain—The series of different nuclides into which a nuclide will change until a stable nuclide has been formed. During decay, nuclides may transform many times.

Disintegration—See decay.

Dose—A measurement of the quantity of energy absorbed per unit mass from any kind of ionizing radiation, also called absorbed dose. The traditional unit of absorbed dose is the rad.

Duplicate sample—A second sample randomly selected from a population of interest to assist in the evaluation of sample variation.

Effective dose equivalent—The summation of the weighting factor for tissue multiplied by the dose equivalent to tissue.

Electret ion chamber—An ionization chamber made up of polypropylene plastic which provides a nearly air-equivalent chamber. EICs are used to measure cumulative total of environmental gamma radiation exposure.

Exposure—A measure of ionization produced in air by x-rays or gamma rays. Unlike dose, exposure refers to the potential of receiving radiation. The traditional unit is the roentgen.

Fission—The splitting of nuclei by neutrons.

Gamma rays—Electromagnetic waves or photons emitted from the nucleus of an atom. Gamma radiation is very penetrating and is best attenuated by dense materials such as lead. Technetium-99, barium-137, and iodine-131 all produce gamma rays.

Gamma spectroscopy—Technique used to determine the distribution of radionuclides in a sample. Gamma spectroscopy identifies radionuclides since the gamma ray spectrum is characteristic for the radionuclides present in the sample.

Gas-flow proportional counting—Technique used to make gross alpha and gross beta screening measurements in a sample. Uses a gas-filled detector under certain conditions. Under these conditions, the number of counts in the detector is proportional to the number of ionization events taking place.

Gross alpha—Total alpha activity detected. Assumes all activity due to a single radionuclide with no species identified or decay corrected.

Gross beta—Total beta activity detected. Assumes all activity due to a single radionuclide with no species identified or decay corrected.

Half-life—The time it takes for one half of the atoms of a particular radionuclide to decay into another nuclear form. Measured half-lives vary from less than millionths of a second to billions of years.

Health physics—The interdisciplinary science and application of science for the radiation protection of humans and the environment. Health physics combines the elements of physics, biology, chemistry, statistics and electronic instrumentation to provide information that can be used to protect individuals from the effects of radiation.

High-pressure ionization chamber—A pressurized ion chamber is a sensitive photon detector capable of real-time measurements and provides real-time environmental gamma radiation exposure measurements.

In situ gamma spectroscopy—Gamma spectroscopic measurements performed *in situ*. The detector is placed directly over the area being analyzed. The advantage to this technique is that samples are not taken, which, in turn, minimizes the potential for cross-contamination and waste production.

Injection well—A well used for the disposal of wastewater.

Ionization—The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions (charged particles). High temperature, electrical discharge, nuclear radiation, and x-rays can cause ionization.

Ionizing radiation—Radiation with enough energy to remove tightly bound electrons from their orbits during an interaction with an atom, causing the atom to become charged or ionized.

Isotope—One of two or more atoms that have the same number of protons but a different number of neutrons in their nuclei. The atoms have nearly the same chemical properties, but their physical properties often differ. A radioactive isotope is called a radioisotope.

Liquid scintillation counting—A counting technique used to measure low-energy beta particles or alpha particles that involves the dissolution of the sample to be counted directly into a liquid scintillator.

Low-level radioactive waste—Waste that does not generally require shielding or heat removal, usually possessing small transuranic content.

Mean—Arithmetical average of a set of numbers.

Minimum detectable activity (MDA)—An *a priori* estimate of the activity that can be identified in a sample with 95% confidence under specified measurement conditions.

Minimum detectable concentration (MDC)—An *a priori* estimate of the activity concentration that can be identified with 95% confidence under a specified set of measurement conditions.

Non-ionizing radiation—Radiation lacking the energy to remove tightly bound electrons from their orbits around atoms. Examples are microwaves and visible light.

Nuclides—A general term used to denote the core, or nucleus, of all known atoms, both stable and unstable.

Neutrons—Neutral particles that are normally contained in the nucleus of all atoms, but may be removed by various interactions or processes like collision and fission.

Perched ground water—A layer of water-saturated sediment or rock separated from the underlying aquifer by unsaturated sediment or rock.

Perched water table—The upper surface of a body of perched water.

Percolation pond—Unlined wastewater pond where some of the water infiltrates into the ground.

pH—A measure of the acidity or alkalinity of a chemical solution; the negative log of the hydrogen ion concentration of a solution.

PM₁₀—All particulate matter in the ambient air with an aerodynamic diameter less than or equal to 10 micrometers. This size fraction is presumed to be respirable and is therefore of special interest.

Precision—A qualitative term used to describe the amount of random error in the measurement process, precision is a measure of the degree to which data generated from repeated measurements differ from one another.

Quality assurance—A management function that deals with setting policy and running an administrative system of management controls that cover planning, implementation, and review of data collection activities.

Quality control—Typically, all the scientific precautions, such as calibrations of equipment and duplicate sampling, that are needed to acquire data of known and adequate quality. Quality control is technical in nature and is implemented at the project level.

Radiation—Energy in transit in the form of high-speed particles and electromagnetic waves.

Radiation dose—The amount of energy deposited in biological tissues per weight of tissue.

Radioactive contamination—Radioactive material in an unwanted place.

Radioactive material—Any material that contains radioactive atoms.

Radioactivity—The spontaneous transformation of an unstable atom, which often results in the emission of radiation. This process is referred to as a transformation, a decay, or a disintegration of an atom.

Radioisotope—An unstable isotope or element that decays or disintegrates spontaneously, emitting radiation.

Radionuclide—A radioactive nuclide.

Sample variance—A measure of the dispersion of varieties observed in a sample expressed as a function of the squared deviations from the sample average.

Secondary maximum contaminant level—National drinking water standards regulating contaminants that primarily affect the aesthetic qualities of drinking water. At considerably higher concentrations, these contaminants may become health concerns.

Sigma (standard deviation)—A measure of the variability of a set of values; the square root of the variance.

Spent nuclear fuel—Nuclear fuel that has been removed from a reactor after being used to produce power.

Split sample—The type of replicate sample produced when a laboratory divides one sample into subsamples.

Thermoluminescent dosimeter—A monitoring device that can be worn by an individual or placed in the environment to measure total gamma radiation during a period of time.

Transuranic waste—Waste that contains isotopes above uranium in the periodic table of chemical elements in levels exceeding 100 nanocuries per gram. Typically, transuranic waste contains by-products of fuel assembly, weapons fabrication, and/or reprocessing operations.

Tritium (H-3)—A radioactive isotope of hydrogen that has two neutrons and one proton in the nucleus.

X rays—Electromagnetic waves or photons not emitted from the nucleus, but normally emitted by energy changes in electrons. These energy changes occur either in electron orbital shells that surround an atom or during the process of slowing energy down, such as in an x-ray machine.

Acronyms

AIP—Agreement-in-principle

ANL-W—Argonne National Laboratory- West

BBWI—Bechtel BWXT Idaho, LLC

CERCLA—Comprehensive Environmental Response, Compensation, and Liability Act, also known as Superfund

CFA—Central Facilities Area

DOE—U.S. Department of Energy

DQO—Data Quality Objective

EIC—Electret ion chamber

EPA—U.S. Environmental Protection Agency

ESER – Environmental Surveillance Education and Research Program

ESP—Environmental Surveillance Program

HTO – Tritium, tritiated water

HPIC—High-pressure ionization chamber

IBL—State of Idaho Department of Health and Welfare Bureau of Laboratories

ICP—Inductively Coupled Plasma Emission Spectroscopy

INTEC—Idaho Nuclear Technology and Engineering Center (renamed in 1998 from Idaho Chemical Processing Plant).

INEEL—Idaho National Engineering and Environmental Laboratory

INEEL OP—Idaho National Engineering and Environmental Laboratory Oversight Program

ISU EML—Idaho State University Environmental Monitoring Laboratory

LMITCO—Lockheed Martin Idaho Technologies Company

MAPEP—Mixed Analyte Performance Evaluation Program

MCL—maximum contaminant level

MDA—minimum detectable activity

MDC—minimum detectable concentration

NIST—National Institute of Standards and Technology

QATF—Environmental Radiation Quality Assurance Task Force of the Pacific Northwest

NOAA—National Oceanic and Atmospheric Administration

NRF—Naval Reactors Facility

PBF—Power Burst Facility

QA—Quality Assurance

RCRA—Resource Conservation and Recovery Act

ROD—Record of Decision

RWMC—Radioactive Waste Management Complex

SB—Shoshone-Bannock Tribes

SMCL—secondary maximum contaminant level

TAN—Test Area North

TLD—Thermoluminescent Dosimeter

TKN – Total Kjeldahl Nitrogen

TRA—Test Reactor Area

USGS—U.S. Geological Survey

VOC—Volatile Organic Compounds

Units

Curie (Ci)—A unit used to measure radioactivity. One curie equals that quantity of a radioactive material that will have 37,000,000,000 transformations in one second. Often radioactivity is expressed in smaller units: thousandths (mCi), millionths (uCi), billionths (nCi), or trillionths (pCi) of a curie. The International Standard (SI) unit that is comparative to the curie is the becquerel (Bq). There are 3.7×10^{10} Bq in one curie.

Rad—Acronym for radiation absorbed dose. The rad is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed by some material, and is used for any type of radiation and any material. One rad is defined as the absorption of 100 ergs per gram of material. The unit rad can be used for any type of radiation, but it does not describe the biological effects from different radiations. The International Standard (SI) unit that is comparative to the rad is the gray (Gy). There are 100 rads in one gray.

Rem—Acronym for roentgen equivalent in man. The rem is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of thousandths of a rem, or mrem. To determine equivalent dose (rem), the absorbed dose (rad) is multiplied by a quality factor (Q) that is unique to the type of incident radiation. The International Standard (SI) unit that is comparative to the rem is the sievert (Sv). There are 100 rem in one sievert.

Roentgen (R)—The roentgen is a unit used to measure a quantity called exposure, but only when used to describe an amount of gamma and X-rays in air. One roentgen is equal to depositing to 2.58×10^{-4} coulombs of energy per kg of dry air, and is a measure of the ionizations of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma and x-rays.

SI Prefixes—Many units are broken down into smaller units or expressed as multiples using standard metric prefixes. As examples, a kilobecquerel (kBq) is 1000 becquerels, a millirad (mrad) is a thousandth of a rad, a microrem (urem) is a millionth of a rem, a nanogram (ng) is a billionth of a gram, and a picocurie (pCi) is a trillionth of a curie.